THE EAST AFRICAN AGRICULTURAL JOURNAL

IMPERIAL MYCOLOGICAL INSTITUTE
17 DEC 1940

of

KENYA
TANGANYIKA
UGANDA AND
ZANZIBAR

Vol. VI—No. 2

OCTOBER
1940

Price
Sh. 1/25

IN THIS ISSUE:

TERMITES IN EAST AFRICA:
I—GENERAL BIOLOGY
II—THE BIOLOGY AND CONTROL OF TERMITES DAMAGING GRASSLAND

RECENT OBSERVATIONS ON THE FEEDING VALUES OF SOME LOCAL FOODSTUFFS

A SMALL FILTERING PLANT

THE NUTRITIVE VALUE OF THE BANANA

SOME OBSERVATIONS ON POULTRY

IMPRESSIONS OF THE COFFEE-GROWING IN EAST AND CENTRAL AFRICA—II

THE ERADICATION OF THORN-TREES

NOTES ON ANIMAL DISEASES

Mitchell Cotts & Co.

(EAST AFRICA) LIMITED

NAIROBI

Branches MOMBASA, DAR ES SALAAM

GENERAL MERCHANTS

in the interests

of the Agricultural Communities

of these Territories

support

the publication of this Journal

Successful Stock Breeders

ALL USE

Dried Brewers' Yeast and Cod Liver Oil

One dessertspoonful of Cod Liver Oil and one ounce of Brewers' Yeast in the evening feed of separated milk will enable you to rear calves with equal growth and development to whole milk

The K. F. A. have limited stocks of both these Commodities

Kenya Farmers' Association

(Co-operative) Limited

NAKURU and BRANCHES

Make Your Engineering Problem Ours

OUR QUALIFIED ENGINEERS ARE AT YOUR SERVICE FOR ALL ELECTRICAL, MECHANICAL AND WATER SCHEMES

Stocks of

Crompton Parkinson Electrical Equipment
Petter Engines and Lighting Sets
Goodwin Contractors' Plant (Concrete Mixers etc.)
Braithwaite's Sectional Steel Tanks
Crypton Battery Charging Plant
C.A.V. Batteries for Cars
Green's Lawn Mowers
"Norge" Refrigerators
Shafting, Belting, Pulleys, Plummer Blocks, etc.

KETTLES-ROY & TYSONS (Msa) Limited

Box 100, NAIROBI and Branches

Kenya and Uganda Railways and Harbours

Circular Rail and Lake Steamer Tours

BETWEEN

KENYA, UGANDA, TANGANYIKA AND THE BELGIAN CONGO

OCCUPYING FROM 6 TO 38 DAYS

CAN BE ARRANGED AT

REDUCED FARES

THROUGHOUT THE YEAR

FULL PARTICULARS ON APPLICATION TO ANY STATION OR PORT

OR TO

Messrs THOS COOK & SON, Ltd., NAIROBI & MOMBASA

Insure Against the Milk-Robber

THE normal milk-yield has dropped all round; but in some cases it is much more serious than in others. There must be a good reason—bloodsucking lice are aggravating the ill-effects of winter.

These parasites reproduce at an enormous rate. They transfer themselves from one beast to another, drain their life-blood and cause unbearable irritation. Infested animals lose condition by the day, the milk-yield drops steadily, and working oxen fail to give of their best.

If your animals are being attacked by lice, there is no time to lose—the cattle are suffering and you're being robbed. Dip all your cattle twice, at 10–14 days interval, in a reliable cattle dip to which Cooper's Lice Preparation has been added. This will eradicate all lice, yet the cost of Cooper's Lice Preparation for both dippings is only a farthing per beast. Economical, effective and safe—ask any farmer who has tried it. Our free booklet, "Controlling Ticks and Other Cattle Pests," gives further valuable information. Write for your copy.

Cooper's Lice Preparation

Sold by all good stores in one-gallon drums—sufficient for 1,000 gallons of dipping solution

COOPER & NEPHEWS, S.Af. (Pty.) Ltd., P.O. Box 596, NAIROBI

SISAL PRODUCTS

(East Africa) Limited

Ruiru, Kenya Colony

Manufacturers of Sisaltex Sacks, Hessian Cloths, Matting, Ropes and Twines

Exporters of Carded Flume Tows and Carded Undergrade Fibres

Enquiries may be made to us at Ruiru, Kenya Colony

OR

to any of our Agents

For Kenya, Uganda, Tanganyika & Zanzibar

The African Mercantile Co. Ltd.—All Branches in East Africa

The Kenya Farmers' Association (Co-operative) Ltd.
All Branches in East Africa

For Belgian Congo

Messrs. Jardine Matheson & Co. (E.A.) Ltd.
P.O. Box 1051, Nairobi

Messrs. F. Cattoir & Co., P.O. Box 781, Nairobi

For Union of South Africa

Messrs. Hochschild & Co., P.O. Box 7741, Johannesburg

NATIONAL BANK OF INDIA

LIMITED

(INCORPORATED IN THE UNITED KINGDOM)

ESTABLISHED IN 1863

Bankers to the Governments of Kenya, Uganda and Zanzibar

HEAD OFFICE: 26 BISHOPSGATE, LONDON, E.C.2.

Subscribed Capital	£4,000,000
Paid-up Capital	£2,000,000
Reserve Fund	£2,200,000

BRANCHES IN EAST AFRICA:

Mombasa, Nairobi, Nakuru, Kisumu, Entebbe, Kampala, Jinja, Zanzibar, Dar es Salaam, Tanga, and Mwanza

Also throughout India, Burma, Ceylon, and at Aden

Agents throughout the World

Every description of Banking business transacted

VITHALDAS HARIDAS & Co., Limited

General Managers for

UGANDA (KAKIRA) SUGAR WORKS, LTD. (Incorporated in Uganda)

Associated Firms—

(1) KENYA SUGAR LIMITED (Incorporated in Kenya)

(2) NILE INDUSTRIAL & TOBACCO CO., LTD.

SUGAR MANUFACTURERS, GINNERS AND COTTON MERCHANTS TOBACCO MANUFACTURERS, IMPORTERS AND EXPORTERS

KAKIRA SUGAR WORKS.—Holding about 14,000 acres of land, mostly under cultivation, at Mile 9, Jinja–Iganga Road. Employing about 5,000 Africans, 200 Indians, Europeans, Mauritians. About 40 miles of Light Railway. Water supply to the factory by means of pumping plant on Lake Victoria. Factory equipped with a new modern type 15-roller mill of John McNeil & Co., Ltd., Glasgow. Telephones: Kakira Factory, 325; Jinja Office, 229, 221, 379, 362. P.O. Box 54, Jinja, Uganda.

RAMISI SUGAR WORKS AND PLANTATIONS.—At Ramisi Estate, Digo District; Gazi Sisal Plantations, near Mombasa. Box 158, Mombasa.

TOBACCO FACTORY.—At Mile 10, Kakira–Jinja–Iganga Road.

COTTON GINNERIES—

Uganda.—(1) Bukoboli, (2) Busowa, (3) Bubinga, (4) Kamuli, (5) Mbulamuti, (6) Kakira, (7) Kabiaza, (8) Butiru, (9) Kabiramaido, (10) Pilitok, (11) Amaich, (12) Aboki, (13) Chagweri, (14) Batta, (15) Jaber, (16) Kalaki. **Kenya:** Malikisi. **Tanganyika:** Ruvu and Kiberege.

Other Plantations, totalling about 4,000 *acres Freehold Land—*

1. Bukoboli : 2. Busowa : 3. Bukona

After a hard day

there is nothing like a

Johnnie Walker

TO BUCK YOU UP

Born 1820 still going strong

Since 1877

- **Smith, Mackenzie & Co., Ltd. have served EAST AFRICA for all requirements**

We shall continue to do so

Smith Mackenzie & Co., Ltd.

NAIROBI

Mombasa, Dar es Salaam, Zanzibar, Tanga, Lindi, Lamu & Kampala

BARCLAYS BANK (DOMINION, COLONIAL AND OVERSEAS)

(Incorporated in the United Kingdom)

BRANCHES IN EAST AFRICA:

KENYA

Eldoret — Kisumu — Kitale — Mombasa — Nairobi — Nakuru

UGANDA

Jinja — Kampala

TANGANYIKA TERRITORY

Arusha — Bukoba — Chunya — Dar es Salaam — Iringa — Mbeya — Moshi
Mwanza — Tabora — Tanga

AND

THROUGHOUT AFRICA

British West Indies — British Guiana — Mauritius — Palestine — Cyprus
Malta — Gibraltar — Liverpool — Manchester — New York (Agency)

WORLD-WIDE BANKING SERVICE FOR TRAVEL AND TRADE

HEAD OFFICE: 54 LOMBARD STREET, LONDON, E.C.3

KETTLES ROY & TYSON (MSA.) LTD.
Representatives: Kenya, Uganda, Tanganyika

The Standard Bank of South Africa, Ltd.

(INCORPORATED IN THE UNITED KINGDOM)

Bankers to the Imperial Government in South Africa, and to the Governments of Northern Rhodesia, Southern Rhodesia, Nyasaland and Tanganyika Territory

CAPITAL (AUTHORIZED AND SUBSCRIBED)	**£10,000,000**
CAPITAL (PAID UP) : : : : :	**£2,500,000**
RESERVE FUND : : : : :	**£3,000,000**

HEAD OFFICE: 10 Clements Lane, Lombard Street, and 77 King William Street, London, E.C.4.

London Wall Branch: 63 London Wall, E.C.2.

West End Branch: 9 Northumberland Avenue, W.C.2.

New York Agency: 67 Wall Street.

The Bank has over 370 branches in Africa, including 20 situated in the East African Territories

Travellers' Cheques and Letters of Credit issued

Executor and Trustee Business conducted. A booklet detailing the Bank's terms and conditions of appointment as Executor, Trustee, etc., in East Africa may be obtained at any branch

Branches at—

NAIROBI

KILINDINI

The East African Coffee Curing Co., Ltd.

Amalgamating—

The Nairobi Coffee Curing Co., Ltd.
The Old East African Trading Co., Ltd.
Mitchell Cotts & Co. (East Africa) Ltd.
Kenya Coffee Curing Works
Dawson & Yonge
Kivoga

WATER BORING

Increase the value of your land by establishing a permanent and pure water supply

ESTIMATES and advice given free and without obligation

Craelius East African Drilling Co., Ltd.

Corner House, Hardinge Street, NAIROBI
P.O. Box 90 *Grams:* **" Craelius Nairobi"**

FINDLATER'S PORTS & SHERRIES ARE POPULAR

THROUGHOUT EAST AFRICA

BRITISH INDIA STEAM NAVIGATION CO. LTD.

ON THE
World's Highways and Byways
TRAVEL

B.I. WAYS

BRITISH INDIA STEAM NAVIGATION CO. LTD.

Frequent services are being maintained to the United Kingdom, India, South Africa and Coastal Ports. Intending passengers are invited to register their requirements.

All sailings are subject to change or deviation, with or without notice. Please apply to Agents for further information.

Smith Mackenzie & Co., Ltd.

Mombasa, Tanga, Dar es Salaam, Zanzibar, Lindi, Lamu & Nairobi

- It goes much further
- It spreads more readily
- Retains the surface ridges
- Resists the hottest sun
- Remains tacky in all weathers
- Has a substantially longer life

Guaranteed free from mineral oil or other harmful admixture

Sole Agents:

GAILEY & ROBERTS LTD.
NAIROBI

Branches at:

NAKURU, ELDORET, KISUMU, JINJA, KAMPALA, DAR ES SALAAM

THE EAST AFRICAN AGRICULTURAL JOURNAL

Vol. VI **OCTOBER, 1940** **No. 2**

Subscription Sh. 5 per volume, or Sh. 1/25 per copy, post free, payable through any Agricultural Officer, or to the Government Printer, P.O. Box 128, Nairobi, to whom all business communications should be addressed. (Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.) Editorial correspondence should be addressed to the Editor, Amani, via Tanga, Tanganyika Territory.

The Editor does not hold himself responsible for opinions expressed by contributors.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Manuscripts should conform with the recommendations contained in *Notes for Authors*, which may be obtained from the Government Printer, Nairobi, or from a member of the Editorial Board.

Twenty-five separates of original articles will be sent free to authors if application is made at the time the manuscript is submitted.

Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to Amani.

CONTENTS

	PAGE
Leader	61
Termites in East Africa: I—General Biology (W. Victor Harris)	62
Termites in East Africa: II—The Biology and Control of Termites Damaging Grassland (H. Wilkinson)	67
Notes on Plant Diseases—Nematode Disease of Oyster Nut (R. M. Nattrass)	73
Impressions of the Coffee-growing in East and Central Africa—II (Dr. Hille Ris Lambers)	74
Grasses as Indicator Plants in Uganda—II (A. S. Thomas)	77
A Home-made Cow Stauchion (R. R. Sharp)	81
Notes on Land Tenure—I (V. Liversage)	83
Wounds	86
Some Recent Observations on the Feeding Values of some local Animal Foodstuffs (M. H. French)	87
The Eradication of Thorn Trees (J. D. Scott)	91
Reviews	92
The American Cotton-growing Industry: Some Impressions—II (H. R. Hosking)	98
A Small Filtering Plant (C. T. Cranswick)	103
The Nutritive Value of Some Tanganyika Foods—I (W. D. Raymond)	105
The Responsibilities of the Scientific Worker	108
Some Observations on Poultry (M. H. French)	109
Notes on Animal Diseases (Kenya Veterinary Department)	114
Supply of Derris Planting Material	116

INDEX TO ADVERTISERS

	PAGE
African Mercantile Co., Ltd. (Dunlop)	Cover Page 4
Barclays Bank (D. C. & O.)	VIII
British India Steam Navigation Co.	XI
Cooper and Nephews S.A. (Pty.), Ltd.	IV
Cooper, Pegler & Co., Ltd.	XIV
Craelius East African Drilling Co., Ltd.	X
East African Coffee Curing Co., Ltd.	IX
Findlaters	X
Gailey and Roberts, Ltd.	XII
Johnnie Walker	VII
Karen Estates, Ltd.	XIV
Kenya Advertising Corporation	XIV
Kenya & Uganda Railways & Harbours	III
Kenya Farmers' Association (Co-operative), Ltd.	I
Kettles-Roy & Tysons (Msa.), Ltd.	II
Kettles-Roy & Tysons (Msa.), Ltd. (Dewars)	VIII
Mitchell Cotts & Co.	Cover page 2
National Bank of India, Ltd.	VI
Sisal Products (East Africa), Ltd.	V
Smith Mackenzie & Co., Ltd.	VII
Standard Bank of South Africa, Ltd.	IX
Vithaldas Haridas & Co., Ltd.	VI

SPRAYING MACHINERY

FOR APPLYING ALL WASHES AND DUSTS, LIMEWASH, CREOSOTE AND DISINFECTANTS

There is the right machine for every job—Ask a friend who is using a **Vermorel** Sprayer

VERMOREL FLAME THROWER

This sprayer, which is used for locust destruction, and weed and scrub burning work, is simply but strongly constructed and easy to use.

Brief specifications: Brass Alloy Tank, complete with 3 ft. delivery tubing and special Flame-throwing Lance. Weight complete 14 lb.

Made in two sizes—

1¼ gallon tank, **115/-** complete.
5 gallon tank, **154/-** complete.

Prices ex Warehouse, London

ALL TYPES OF WET AND DRY SPRAYERS MADE AND STOCKED
Capacities from 2¼ pints to 220 gallons. Prices from 5/- to £202-10-0

Complete Catalogue and List of Stockists in East Africa (Main Agents and/or Distributors: J. G. Aronson Ltd., P.O. Box 681, Nairobi, and T. Thompson, P.O. Box 1119, Nairobi) from—

COOPER, PEGLER & Co., Ltd.

31-31a Clifton St., Finsbury Square, LONDON, E.C. 2

PROPERTY

IS TO-DAY THE BEST

INVESTMENT

KAREN ESTATES Ltd. have recently acquired a new property at Ngong, which includes a considerable area of indigenous forest

20 Acre Plots at £25 to £30 per Acre

Extended Terms of Payment

ELECTRIC LIGHT :: WATER

Apply Box 129, Nairobi. Phone 2441

For

ADVERTISING SPACE

IN THIS JOURNAL

Apply to

KENYA ADVERTISING CORPORATION LIMITED

Rhodes House
Delamere Avenue
NAIROBI

P.O. Box 563 Telephone 2367

THE EAST AFRICAN AGRICULTURAL JOURNAL

Issued under the Authority of the East African Governors' Conference and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue).

Editor: Director, East African Agricultural Research Station, Amani.

Editorial Board: Directors of Agriculture, Kenya, Tanganyika, Uganda, and Zanzibar.

Assistant Editors: R. E. Moreau, Amani; Mrs. Holmes Jackson, Department of Agriculture, Nairobi.

FOREWORD

The Cumulative Index issued with this number of the Journal provides a convenient gauge of the amount of attention that has been devoted to different subjects in the first five volumes. Coffee has the largest number of entries with a long lead over any other crop. Soil is very properly the subject with the next largest number of entries, but certain subjects of great importance in East African economy are found to have been neglected beyond their deserts; and for two of them, termites and the nutritive values of local human foods, this number of the Journal begins to remedy the deficiency.

The termites are a group of insects which, in the variety of their effects, direct and indirect, on their environment, surpass all others in importance. Their most obvious and familiar characteristic is of course their destructiveness. There can be few of us who have lived for any length of time in East Africa who have not suffered from their insatiable hunger for wood, a necessity of life to them which leads them to devour, most secretly and unexpectedly from the inside, anything from a garden label to a godown. Such depredations can be countered by the use of more or less immune woods, by adopting certain building devices, and by vigilance; but a form of destruction almost more extensive and more difficult to combat is due to some species of termite that, driven by the same fundamental cellulose-hunger, cut up and sweep away to their underground nests the dry grass that in drought years is more than ever needed by live stock. The secondary damage resulting from this wholesale baring of the soil is almost worse than the primary, for the naked land is laid open defenceless to the erosive effects of the next downpour of rain.

In the pages that follow Mr. Harris introduces the subject of the general biology of termites, a varied and most singular chapter of natural history. In the second part Mr. Wilkinson deals especially with the harvester-termites, quoting a South African work on the subject, and suggesting methods of control. His article shows incidentally how much remains to be done on termites in Kenya, for the identification of the insects most concerned in grassland damage remains uncertain. In subsequent numbers of the Journal Mr. Harris proposes to set out the present knowledge of the distribution of the different termites in East Africa, with more detailed studies of their life-histories. Later it may be possible to include in the series an article summarizing the available information on that curious and little-understood aspect of termite biology, the ability of some species to concentrate lime in their "anthills," with important consequences for the agriculturist and even for the road-maker.

Attention to diet, based on a knowledge of what its constituent articles provide to their consumer, is of fundamental importance to everyone concerned with the bodily wellbeing of the African, whether from altruistic motives or as a business proposition, a fact very well realized by the great employing corporations of South Africa. In this number of the Journal, Raymond and Jojo present the first of a series of studies of East African foods. It is appropriate that they should have chosen to begin with the banana; for although that fruit forms the staple food of hundreds of thousands of our fellow-subjects its appearances in recent East African agricultural literature have consisted of little more than incidental references to the plant as a nurse for coffee. Another use of the same plant in human economy is described in this number by French in an article, which will interest many readers, on the nutritive value of banana plant chop and other unfamiliar stock-feeds.

For previous issues of the Journal see special note on page 97

TERMITES IN EAST AFRICA
I—GENERAL BIOLOGY*

By W. Victor Harris, M.Sc., A.I.C.T.A., F.R.E.S., Entomologist, Department of Agriculture, Tanganyika Territory

(*Received for publication 6th May,* 1940)

Among the many insect pests which attack man's worldly goods in the tropics, and not counting those which attack man himself and his animals, pride of place for causing annoyance and actual monetary loss undoubtedly belongs to the termite or white ant. In all the warmer parts of the world termites are vigorously feeding on cellulose, either in its natural state as dead and dying trees, herbs and grasses, or as timber work in its innumerable forms, or as manufactured articles such as paper and clothing. The blame for all this loss cannot be put entirely upon the termites, for they had fitted themselves into the scheme of things millions of years before man appeared on the earth, and if man then comes along and puts under their very noses limitless supplies of food without any effort at protecting it from them, the termites cannot be expected to ignore the opportunity. Termite injury is so general throughout the tropics, so much an everyday event that has been going on since the beginning, that there is a general apathy towards it and the loss it entails. Termites lack the spectacular appeal of the swarming locust, or any other epidemic crop pest whose depredations can be contrasted with the uninjured harvests of a previous season, so they go on grinding out their toll year after year. It is stated that the loss annually sustained in the United States of America by termite action is in excess of £8,000,000, and it must be borne in mind that this is actual loss by material damage and not just by failure to reap something that was anticipated, which is the usual form of loss caused by crop pests. In spite of the impressive sum total which a world estimate of their damage would present, termites have a credit side which ought not to be neglected, in that, as will be discussed more fully later in these notes, they are an important link in the breaking-up of vegetable matter and the return of its components to the earth for further use. They play a part, too, in the movement of soil, analogous to that played by the earthworm in temperate climates.

Termites are social insects, living in communities on a highly organized basis, which has for centuries exercised the interest of both naturalists and philosophers, who would draw a moral for man's benefit from the behaviour of ant and bee. Smeathman, an Englishman who visited the West Coast of Africa in 1781, has provided an account of the large mound-building termite which is a model of straightforward observation which should have influenced all who followed him.

In Latin *termes* means a branch cut off a tree. It was used by medieval writers on natural history for an insect living in wood; in this sense it was adopted by Linné in 1758 for a group of insects and subsequently restricted by later workers to those insects which we know as "termites". *Termes* is used nowadays for one genus of the group to which Linné gave the name. "White ant" is popularly used among English-speaking people, *"fourmi blanche"* by the French, *"weisse Ameise"* by the Germans, and so on. Since white ants are no more closely related to true ants than, for example, a Jerusalem artichoke is to a globe artichoke, this common name is misleading. The use of the name "termite" has the additional value of being constant throughout most European languages, and is free from association, conscious or sub-conscious, with any other common insect.

A long time back in the earth's history, even as geologists reckon time, when insects had progressed only a little way along the road that has led to the many and varied forms we know to-day, the ancestors of the termites broke away from this main road and started on a line of their own. As this was about the time that the earliest cockroaches were appearing, it is to these insects that termites bear the closest relation. It is generally assumed that termites arose during the Tertiary period, the age of reptiles, though recent work in Russia (Zalessky, 1937) suggests the earlier Middle Permian. The antiquity of termites is shown by the close resemblance of specimens in fossil beds of Oligocene and Miocene periods to forms now alive.

*This series, as planned by Mr. Harris, was to consist of the non-technical introduction of the subject of termites here given, followed in successive numbers of the Journal by a key to the East African termites, territorial lists, notes on their distribution, and other detailed articles. Shortly after the receipt of Part I of the series Mr. Wilkinson's article, which had been conceived quite independently, arrived, and since early publication of the control measures advocated in his concluding part seemed desirable his article has been incorporated in the series, at the risk of some disturbance of its arrangement.—*Ed.*

The development of the social habit in termites occurred so early that no trace of a solitary tendency is to be found in any present-day species. There are no solitary termites as there are, for instance solitary bees. The degree of organization of the termite community varies according to the development of the species, and the actual number of individuals forming the community ranges from a few hundred of the *Calotermes* of Southern France and Italy, to the many millions of the large mound builders of the African savannas.

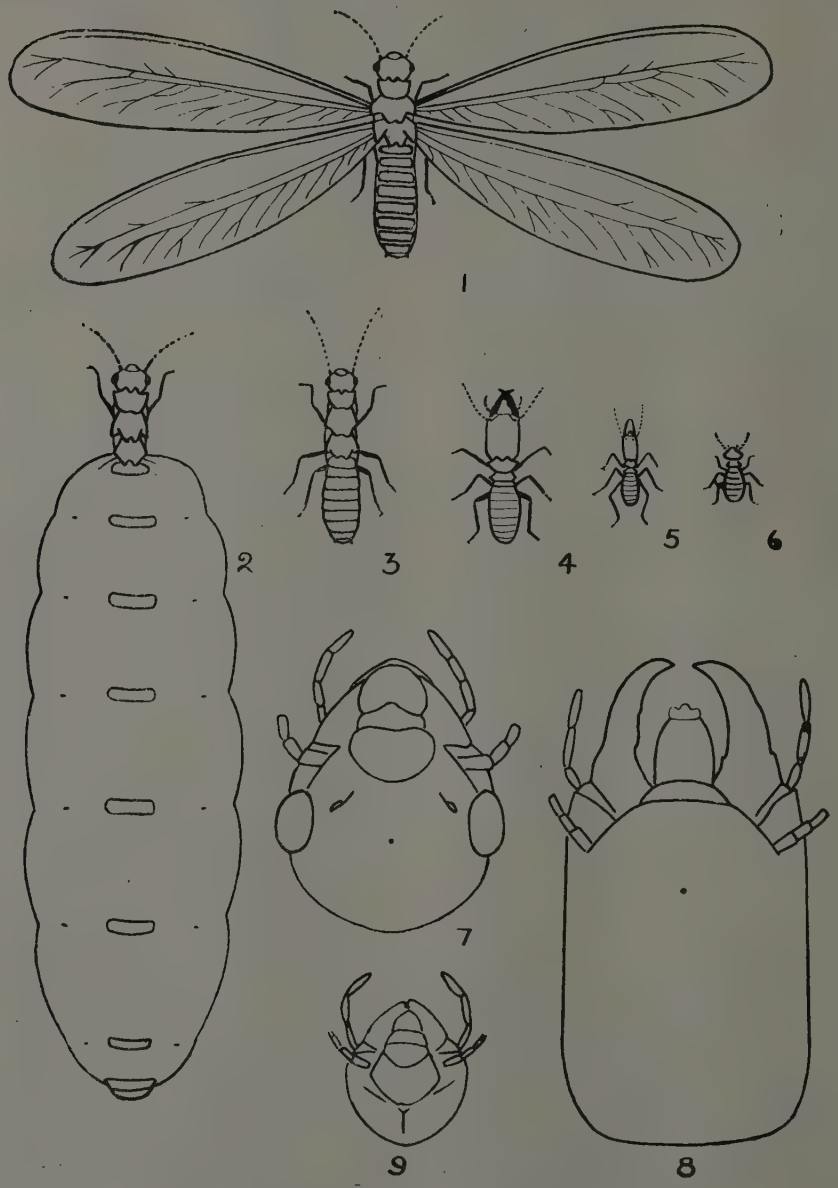
Each termite community contains a pair of functional reproductives, male and female, commonly called the king and queen. Here again they differ from bees and wasps, whose queen is the only functional reproductive in the nest. The king and queen together found the colony. Their functions are limited to reproduction since their offspring are specially adapted to undertake the other duties of the colony, with that consequent division of labour which makes the termite system so successful. With one exception, each genus of termites has a group of individuals specialized for defence and known as soldiers. These soldiers, though sterile, represent both male and female sexes. The work in the more primitive groups of termites is done by the nymphs or young forms of both the reproductive and the soldier castes. Termites hatch from the egg in an active state and grow by a series of moults, like locust hoppers, to their adult forms. During this nymphal state they build, tunnel, gather food and keep the nest clean. The higher groups of termites, particularly the mound builders, have a special caste of workers for these duties and these too represent both males and females. In their early stages the nymphs of all three castes are similar, but as time goes on the wings of the young reproductives begin to show themselves as small pads on the thorax, while the young soldiers show their particular development of the head. The nymphal reproductives on their final moult develop functional wings and become generally dark in colour. These adult termites, as they now are, leave the nest in considerable numbers when the weather is favourable and, pairing off, found new communities. It may so happen that one or other of the royal pair dies owing to age or accident, and in this case the termites are able to replace it by hastening the development of a suitable nymph to produce a substitute or supplementary reproductive. Frequently two or more supplementary queens will be produced to replace the loss of the original queen, for their egg-laying powers are not usually so great. The normal termite colony thus consists of—

The reproductive caste (Figs. 1, 2, 3, 7)—
(*a*) a mature female or queen,
(*b*) a mature male or king;
The soldier caste (Figs. 4, 5, 8)—
(*c*) individuals adapted for protection;
The worker caste (Figs. 6 and 9)—
(*d*) individuals adapted for work;
Nymphs—
(*e*) consisting of undifferentiated young forms, soldier nymphs, worker nymphs, and nymphs, of the reproductive caste with wings in various stages of development;
and at certain seasons—
(*f*) winged reproductives waiting for a suitable opportunity for leaving the colony.

THE CASTES OR FORMS OF TERMITES

(1) *Reproductives.*—The fully developed termites of both sexes are similar in appearance (Fig 1). They are more or less dark-coloured owing to the thickness of their chitinous covering. Their heads are oval, with large compound eyes and a pair of simple eyes or ocelli (Fig. 7). The mouth parts follow the simple biting type as found in the cockroach, with well-developed mandibles. There are two pairs of large membranous wings, the front pair only slightly different from the hind pair, hence the name Isoptera (*iso* equal, *pteron* a wing) given to the order as a whole. The wing venation is reduced in all but the most primitive genera, and the veins themselves are generally but faintly marked. There is a noticeable absence of regular cross veins. Termites possess the ability to shed their wings at will, owing to the presence of a definite line of fracture near the base of the wing. The portion of the wing which remains after shedding is known as the "scale", and the insect retains four of these throughout the rest of its life. This ability to shed the wings is not quite unique to termites, but is found in certain cockroaches. The wing-spread of our East African termites varies from 12 to 90 millimetres. The abdomen consists of ten segments, the last of which bears a pair of short projections or *cerci*. In the female, the *sternum* or lower part of the seventh segment is greatly enlarged, and covers the remaining sterna, forming a convenient way of differentiating the sexes.

The female partner of a pair of termites that have founded a new colony undergoes enlargement of the ovaries, the fat body causes the stretching of the inter-segmental membrane and the chitinous plates of the body segments



PSEUDACANTHOTERMES MILITARIS, Hagen.

FIG. 1.—Winger reproductive or alate, × 2.
FIG. 2.—Queen, some years old, × 2.
FIG. 3.—King, × 2.
FIG. 4.—Major soldier, × 2.
FIG. 5.—Minor soldier, × 2.
FIG. 6.—Worker, × 2.
FIG. 7.—Head of alate, × 14.
FIG. 8.—Head of major soldier, × 14.
FIG. 9.—Head of worker, × 14.

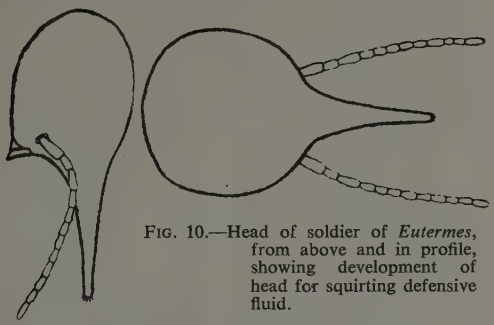


FIG. 10.—Head of soldier of *Eutermes*, from above and in profile, showing development of head for squirting defensive fluid.

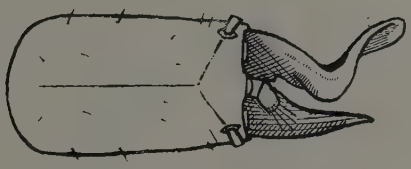


FIG. 11.—Head of soldier of West African *Capritermes*, showing development of mandibles. (Redrawn from Silvestri.)

become dark-coloured islands in a wide expanse of soft white tissue (Fig. 2). The queens, during years of incessant egg production, reach a length, in the large mound-building termites, of five inches. During this time the male continues more or less unaltered in appearance Fig. 3). There is an interesting example of convergent evolution in the queen of the safari ant (*siafu*), *Dorylus*, which exhibits a similar, though not so extensive, tendency to abdominal enlargement.

It is not unusual with certain termites for more than one queen to occur in a colony. This is more common, however, when the queens are supplementary ones, which is to say that they have been brought on from the nymphal stage to replace the original queen, and have not swarmed at the proper season. These supplementary queens have short, undeveloped wing rudiments, and not scales, indicating that they have never had wings. They do not as a rule grow so large as the original queens, hence the necessity for more than one to carry on with the work.

(2) *Workers.*—Unlike the worker caste of the honey bee, termite workers are representative of both sexes. In addition, their development is so far arrested that they cannot produce eggs under any circumstances. Developed solely for work, this caste is small and pale in colour owing to the weak chitinization of the skin, and is the source of the name "white ant." The eyes are either absent or merely relics, except in the harvester termite, which forages for grass out in the open, in bright sunlight. The jaws are well developed for gnawing, being stout and fitted with saw-like teeth. The workers are numerically the most important caste in East African termites. In other parts of the world there are termites with no workers, their duties being performed by the nymphs of reproductive and soldier castes, but these are primitive forms which do not make large colonies. On the whole the form of the worker varies only slightly among different species of termites, so that they are difficult to identify. In some species it is possible to separate the workers into two distinct size-groups, but they do not differ otherwise.

(3) *Soldiers.*—The soldier termites are easily recognized by the great development of their heads and jaws. They are like the workers in that they represent both sexes, and also in possessing lightly chitinized bodies. Their strong specialization for defence and offence and for no other type of work has brought about a greater difference in the head than in either of the other castes. They possess two weapons—their jaws or mandibles, and the ability to secrete a sticky fluid from a pore situated on the front of the head. Certain termite soldiers have reduced their mandibles to a minimum, and concentrated on their second weapon, so that the head has become pear-shaped, and the viscid secretion is squirted with force on the enemy from the opening at the protruding apex of the head (Fig. 10). Others have developed fantastic mandibles; e.g. a West African species (Fig. 11), whose twisted mandibles make a snapping noise for the purpose of frightening its enemies, but are quite incapable of inflicting any injury. The various forms of heads and mandibles provide the simplest means of identifying the numerous species of termites. As with the worker caste, soldier termites are blind, except in the harvester termite.

In a number of species the soldier termites are readily separable into two or more forms, on account not only of the differences in size, but also of distinct differences in shape of head and mandibles (Figs. 4 and 5). There appears to be, in addition, some difference in the duties of the two types of soldiers, correlated with marked difference in appearance. This will be discussed in detail later.

THE TERMITE ECONOMY

The more primitive termites are, with a few exceptions, wood borers. They live in dead branches of trees or the timber work of build-

ings, passing their lives within tunnels carved out of the wood, and only making contact with the outer world when the winged adults fly out at swarming time to found new colonies. There is little or no differentiation of the nests of this group of termites; the royal pair wander about at will, and are not confined to a definite cell. The termites of the next group are also wood borers, but have their main nest in the soil. They make lengthy tunnels of wood-pulp over the bark of trees to reach a dead branch or dead wood surrounding a wound, upon which they feed; or they will make these tunnels over stone walls, particularly in earth mortar in the walls, to reach the roof or ceiling timber. They will carry eggs from the subterranean nest to nurseries made in the workings in a suitable dead branch, giving these the appearance of nests as the nymphs hatch out, but despite the distance between some of these colonial nests, the connexion with the main nest is maintained. The higher termites are mainly earth dwellers, some being completely subterranean, others producing the great variety of earth mounds. A few species of termites, representing a variety of genera, build their nests on the branches of trees. Connexion with the ground is maintained by means of tunnels on the tree trunk. The nests are made of wood pulp, or carton as it is usually called, with a certain amount of earth incorporated in the outer layer. Internally, these arboreal nests correspond closely with those of related species nesting in the ground.

The nests of the higher termites are of two types, depending on their feeding habits. The large mound-builders and their allies make a series of large chambers connected by small tunnels; the others make a honeycomb structure of small cells with thin partitions of soil or carton. The large chambers contain fungus gardens as described below.

The food of termites is primarily cellulose; that is, wood and other plant tissues. The digestion of such a resistant food is assisted in a number of ways. For instance, the wood-boring termites follow minute fungi and feed on both the fungi and the wood cells which have already been attacked by it. These termites also contain in their alimentary canal an extensive population of minute single-celled animals, protozoa, which assist a great deal in the digestion of woody material. Those termites which possess fungus gardens use woody material for the construction of sponge-like masses on which they cultivate a fungus. The crop of minute white spheres on this comb provides the food at least for the young termites and the royal pair. A portion of fungus comb with white spheres, from a nest of the large mound-building termite, is shown in Plate I (*opposite page* 66). The builders of the honeycomb type of nest do not grow fungus, but appear to feed extensively on humus in the soil. They also collect seeds and grasses, which they store in the nest. The exact method of feeding of this type of termite is as yet imperfectly understood. Most termites collect their food by burrowing, or in the shelter of tunnels constructed of earth or chewed wood particles, but some forage in the open. The harvester termite habitually wanders about in the sunshine, while others come out in large groups in the evening or during cloudy weather.

The relations between different species of termites are various. From open attack and annexation of nests, down through casual encounters, they proceed to occupation of disused parts of a nest, and finally there are small inoffensive communities which appear to be tolerated as guests in odd corners of a colony, in continual contact with the host. Such guest termites are small and defenceless, the soldiers having curiously elongated and apparently useless jaws. Among the occupiers of disused corners of larger mounds are species which appear never to build structures of their own.

There are also present in termite colonies a variety of insects whose relations with their hosts vary from that of true guests to scavengers and actual predators. Beetles are most commonly met with, but flies, caterpillars and bugs are also found, though many of them have undergone such remarkable structural changes that they are not readily identified. Some such associations are specific, while others are more casual. The study of termitophilous insects and their relations with their hosts is one of great interest and has inspired much work in many parts of the world.

The traditional enemies of all termites are ants. Though both insects will inhabit the same rotten log or live in close proximity in the soil, they appear to exist in peace only so long as they do not come in contact. Once the partition is broken, the resulting conflict is bitter, but by no means always a victory for the ant. Some ants live on termites and may be found actively raiding nests. Others merely make the most of opportunity, and reap their best harvest when workers and soldiers come up to the surface at swarming time to speed the winged adults on their way. At swarming time, too, birds and lizards consume large quantities of winged termites, as well as attacking the soldiers and workers on the ground. Among their other enemies, termites are subject to attack by pangolins.

PLATE I

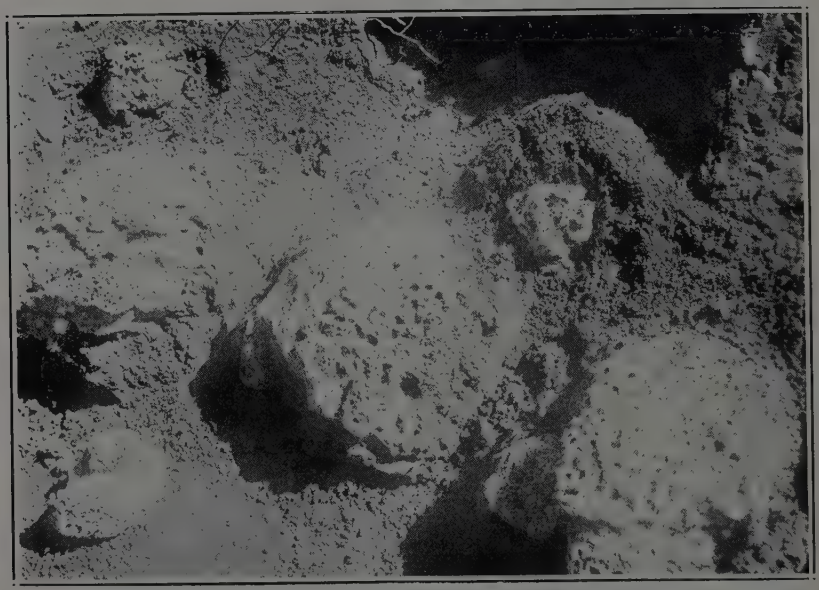
BELLICOSITERMES BELLICOSUS

Fungus garden of the mound-building termite: the white spheres are used as food for young termites and the royal pair.

PLATES II AND III

TERMES BELLICOSUS

The royal cell opened, showing the queen in situ. Approx. 1/10th natural size.



Portion of the nest, showing disposition of fungus gardens and their sponge-like structure. Approx. 1/8th natural size.

TERMITES IN EAST AFRICA

II—THE BIOLOGY AND CONTROL OF TERMITES DAMAGING GRASSLAND

By H. Wilkinson, A.R.C.Sc., F.R.E.S., F.L.S., Senior Entomologist, Kenya Department of Agriculture

(*Received for publication 2nd August,* 1940)

The problem of termites and their control is an ancient one that suddenly loomed into prominence in Kenya as a result of certain recommendations made by Dr. Pole-Evans, who in his report writes as follows:—

"A great deal of destruction to the vegetation and especially to the grass on the Yatta Plateau was being wrought by termites, both harvesters and fungus-growers, and a systematic campaign against these most destructive insects should be instituted at once."

The damage being caused by these insects in the Kamasia and West Suk Reserves was also stressed.

The real difficulty with which we are faced in connexion with the control of termites lies in our lack of knowledge of the types with which we have to deal. The immensity of the problem and lack of staff have precluded any comprehensive study of termites in Kenya, and in fact so little work has been done on this group of insects that we do not know the number of species or even the genera of termites which may be present within the Colony. The problem confronting us, if a comprehensive study of termites is to be made, is vastly more complicated and of wider importance than is generally realized. Not only is it necessary to study the biology of termites but also the practical application of the findings to the needs of agriculture, the architect, the constructional engineer, the builder and timber merchants prominent in the large-scale production and utilization of wood, which will need the willing co-operation of men with a knowledge of these various industries. There is no doubt that such co-operation would be forthcoming immediately the biological aspects had been studied. Therefore the first essential is to determine the particular species of termites that are present within the Colony and to make a detailed study of their life-histories and habits. This will require the full-time services of at least one entomologist for a number of years.

The present article deals only with the two types of termite mentioned by Dr. Pole-Evans, namely "harvesters" and "fungus-growers," which illustrate how necessary it is to know the life-history and habits of the species concerned before control measures are recommended.

At the outset it should be mentioned that while there was little doubt that harvester termites were present within the Colony, specimens with the appearance of harvesters have only recently been received for identification. The specimens mentioned were brought by the Senior Agricultural Chemist from the gorge near Naivasha, and appear similar to *Hodotermes mossambicus*, the chief harvester termite in South Africa.

The following is an extract of an article, "The Harvester Termite," by W. G. H. Coaton, entomologist, which appeared in *Farming in South Africa* for June, 1937 (Vol. 12, pp. 249-252):—

"Thus far the farming community has not realized to what extent the grass on pastures is damaged by harvesters, although this constitutes the most serious form of economic damage caused by this species of termite.

"*Organization.*—The *Hodotermes* or harvester termites are to be seen mowing down grass blades or stalks and carrying the pieces to the numerous small holes in the surface of the ground. Here the hay is deposited to be carried underground when a sufficient supply has been collected or when the termites are forced to cease their activities as the result of attacks by black ants. The insects which cut grass on the surface consist of young and full-grown workers. Soldiers which defend the colony are also found, but in smaller numbers than the workers. They have large, protruding jaws, and never appear on the surface. While the workers are engaged in hay-mowing, a few soldiers will usually be found directly below the surface in the openings of the harvester holes, with their jaws directed towards the ground surface, in order to keep off intruders, such as black ants. When activities cease, the openings of the harvester holes are tightly sealed with wet earth by the workers.

"*The Nest.*—Immediately below the ground surface the harvesting holes lead through a maze of narrow, winding, branching passages into a large series of pockets, approximately three inches in diameter and a quarter of an inch high. These cavities are used by the workers for storing temporarily the collected grass. From these pockets some passages, as thick as a man's little finger, run parallel to the surface, while others descend progressively by a series of steps into the soil where they become larger and in due course connect up with the hives, which constitute the actual nest of the colony. In the neighbourhood of the hives, remarkable mazes of inter-connected flat shelves are found, in all of which supplies of mown grass are stored. These shelves are directly or indirectly connected with the hives of the nest and also with the pockets just below the harvesting holes. From the hives other passages run by a series of steps to the surface, through which the large quantities of soil, which are excavated in the making of the hives and passages, are dumped on to the ground surface in the form of small mounds of sand grains.

"*A colony dug up.*—Near Johannesburg, twenty yards of an infested area of approximately 100 square yards was opened up. In this small area no less than nine nest hives, which were inter-connected by a maze of narrow passages, were exposed. All these hives consequently were parts of one colony. Four of them were bigger than the others, containing large quantities of half-eaten grass, and were densely populated by termites in all stages of development, from small newly hatched larvae to full-grown soldiers and workers. No trace of the queen could be found, although possibly she might have been present in one of these hives just before it was opened. She does not show the marked distension typical of the queens of so many other species of termites, is exceptionally active, and leaves the nest at the least sign of danger. The remaining hives were smaller, and contained only grass, workers and soldiers, and larvae in a fairly advanced stage of development. For this reason it is presumed that these five hives were not true nests, but store-rooms for the quantities of grass collected.

"Each hive consists of a dome-shaped cavity, one to two feet in diameter, situated approximately one to four feet below the ground surface. One case is on record of a hive which was found at a depth of twenty feet. In the cavity of the hive there are hundreds of close-set, inter-connected shelves consisting of a black, brittle material of the thickness of paper. In these shelves large quantities of grass are stored by the termites. Only when such a colony is dug up can a conception be formed of the quantity of grass harvested by the termites and carried underground. Each of the hundreds of pockets, all the hives, and the large number of shelves in their vicinity are closely packed with grass. Only nine hives were dug up, but possibly more than thirty would have been exposed if the whole infested area of 100 square yards had been uncovered. With this large supply of grass stored underground, and the fresh supplies which are constantly introduced to supplement the grass consumed by the ever-increasing numbers of individuals in the colony, it is clear why the presence of a harvester colony in the veldt is usually marked by bare, grassless patches.

"*Damage to grazing.*—The harvester termite collects grass throughout the year, but has now been shown to be most active during the dry months of the year. During seasons of normal rainfall when plant growth is good the harvester will not appreciably affect the carrying capacity of pastures. Their presence is hardly noticeable in such years. But what happens in years of summer drought? Owing to the lack of rain the dry grass, which is soon removed by stock and termites, is not replaced by new growth. There is no decrease in the number of termites in the harvester colonies, and the whole population has still to be fed. If the grass in the vicinity of the nest has been exhausted, the termites are compelled to extend their harvesting passages further and further afield. The limited quantities of grass left ungrazed or surviving the drought are destroyed by the termites. [The fungus-grower termite species, such as *Termes natalensis, Termes badius* and *Termes bellicosus,* are well represented in Kenya, and, in the absence of wood, these species are forced to live mainly on dry grass.] As the grass is mown down by the harvesters, the fungus-growers cover the stubble with clay, under cover of which the plants are destroyed down to the roots. In this way the veldt is practically completely denuded of the vegetation which is so essential for keeping stock alive during periods of drought.

"Ground denuded of vegetation in this way recovers very slowly when once the rains come. Usually chiefly inferior grasses, which appear early in grass succession, are to be found in such localities.

"In the choice of the locality for their nest the harvesters prefer dry, well-drained areas such as hill slopes. Consider for a moment the result of these bare patches of ground, brought about by fungus-growers and harvesters on the slopes. When the rains fall, this lack of vegetal covering could easily be one of the initial causes of soil erosion.

"*Control measures.*—We have already seen that a colony consists of numerous nest hives and a maze of narrow passages, cavities and shelves. The queen is very active and may be present in any one of the hives. At the least sign of danger, she forsakes the hive, which is very difficult to find, and may be located at anything from two to twenty feet below the surface. In these circumstances it can easily be seen that the common method of digging up and destroying the queen is most unpractical. Further, as a result of the long narrow branching passages, methods such as fumigating the colony are equally unserviceable. The only known practical method is the use of bait.

"Cut quantities of grass, preferably hard veldt grasses with narrow leaves, into small pieces about half an inch long. These pieces of grass are then soaked for a few minutes in a solution of 1 lb. sodium arsenite, 8 lb. brown sugar, and 8 gallons of water. The grass is then removed from the solution. The bait may be used in a moist condition, but should preferably be dried and stored in bags so that a good supply is available whenever required. The dry bait is also less unpleasant to use.

"At every opportunity when harvesting activities are observed, the bait should be broadcast on the affected spots after the manner of sowing lucerne seed. A native on horseback can cover the farm daily and scatter a few handfuls of bait wherever activities are seen. The termites will eagerly carry the poisonous bait into the nest, and in time it is consumed by the inmates of the nest. The process of destruction is slow and results cannot be expected immediately. Bait should be regularly strewn over a period of two months or longer. Activity will gradually diminish and will eventually cease altogether if baiting is carried out regularly and thoroughly."

The fungus-growers

The common species of fungus-growers known to be widely distributed in Kenya are *Termes bellicosus, Termes badius, Termes natalensis,* and *Termes transvaalensis.* These are all earth-dwelling termites which may or may not build mounds, according to circumstances. They live in the earth and in wood in contact with the earth, and feed upon wood placed in or on the ground, and from such wood as a centre extend their attacks to wood removed from the ground in buildings of all descriptions, where they may cause serious damage. They destroy the wood, not by attacking it directly from the outside as most insects attack vegetation, but rather by entering inside it from the ground and feeding within the cavity thus made, but always retaining intact an outer protective shell of undamaged wood. To attack wood not in contact with the ground they can be seen building tubes or covered runways of earth from their galleries in the ground over plaster, cement and other materials until wood at higher levels, even to the second story of buildings, is reached. These termites thus habitually live in narrow galleries and passageways, whether in the ground or in the wood being attacked, and are thus protected from many of the accidents, exposures and contacts of the life of most insects.

(See Plates II and III facing page 67.)

The food of termites is primarily cellulose, and is usually obtained from the wood within which their burrows are made. Wood is the most resistant and durable product of vegetation, and, among insects, termites and wood-boring beetles accomplish a unique function in the scheme of nature by their assistance in returning this resistant material to the air and soil from the chemical constituents of which it took its origin. Primarily the species of termites mentioned above avail themselves of cellulose only after the death of the plant, and therefore occur predominantly in stumps, fallen logs, dead trees and in exposed and dead roots. These extensive natural reservoirs are centres from which the termites enter the commercial and industrial products which civilized man fabricates from wood and other forms of cellulose. Man's relation to termites is an important one, since he makes available to the termites large concentrated stores of cellulose in the form of wood in buildings

grouped together in large and small towns, and spaces it conveniently along his lines of communication in pole lines and fence posts, often with exposed sapwood. These foster the local concentrations of infestation, facilitate the spread of termites from one locality to another and assist in the extension of infestations from the already existing natural reservoirs of the different species.

At certain times of the year in all normal colonies vast numbers of winged reproductives, known as *alates*, appear. These winged termites may be present in a nest for as long as three months awaiting certain favourable conditions for swarming. In Kenya swarming flights occur at the beginning of and during the long rains, and it is a common sight at this period to see enormous numbers of what are erroneously termed "flying ants" over wide stretches of country where similar meteorological conditions prevail. From observations made over a period of years, it may be stated that the writer has not observed swarming during the short rains, though it possibly may occur. Flying termites of the species under consideration appear to be weak fliers, and do not travel very far from the nest from which they emerged, and a few hundred yards seems to be the maximum distance travelled during their very short period of flight. These flying *alates* are adult reproductive forms, with males and females approximately in equal numbers. On reaching the ground they can be seen running about or flapping their wings excitedly and within a few minutes the wings are detached at basal sutures. After a few hours the flying termites have disappeared entirely, and nothing of them can be seen except their detached wings lying about the ground in thousands. During the period of their subterranean existence termites are well protected from natural enemies, but during the swarming period they are particularly vulnerable, and it would appear that only a very small proportion of the winged fliers survive to commence a new nest.

Dealation, or the dropping of the wings at the time of swarming, is followed by pairing. There appears to be a great sex attraction at this time, and individuals of opposite sex meeting one another usually arrange themselves in pairs, with the female in front and the male behind, the latter following all the sudden turns and twists of the female. The pairs having met, they shun the light, dig into the earth, or between some piece of wood and the earth, and seal up the opening. Among bees and ants the swarming flight is a mating flight, during which copulation takes place. Among termites, however, niether the reproductive organs nor the sexual instincts are entirely mature on emergence, and copulation takes place some days after the pairing of the males and females. The pairs which are successful in entering the ground and commencing a new nest are then known as the primary king and queen. The queen commences to lay eggs, which at first are relatively few in number, and which hatch in 30 to 50 days into nymphs. Not until these nymphs are old enough to take on the various communal duties of the nest does the queen settle down to her sedentary duties as an egg-producing machine in a specially constructed portion of the nest.

Constitution of a nest

A termite's nest is a great social organization made up of thousands of individuals of different types or castes fitted by inherited structure and instincts to perform various important functions in the life of the colony. In the species under consideration, which belong to the more highly developed Termitidae, the constitution of the nest is very complex. The mature colony consists of adult individuals of workers, soldiers and reproductives such as the king and queen and alates, together with numerous nymphs of the various castes in different stages of development.

Upon opening the galleries of a termite colony the great majority of individuals are seen to be pale, weak-looking insects, usually white in colour. These are the workers and nymphs of the various castes. It is these individuals which by virtue of their numbers and concerted activity accomplish the destruction of wood, the construction of the nest, mounds and runways. Scattered amongst the nymphs and workers is a much smaller number of soldiers, which are distinguished by the greatly enlarged heads and greatly elongated, massive toothed jaws or mandibles. It is the duty of the soldiers to defend the colony against enemies and to protect the workers during certain operations. The social life of the termite colony has brought about a more or less complete dependence of its highly specialized individuals, namely the king and queen, the soldiers and the first instar, upon the nymphs or workers for feeding. All these specialized castes are more or less helpless and if isolated soon starve, since they are unable

to feed themselves. The slow growth of the colony in the first year, when its care is for a time entirely dependent upon the primary king and queen, is probably due to their inability to feed effectively. These specialized individuals and the young nymphs, upon hatching and until after the first moult, are apparently unable to feed upon hard wood, and are fed by the workers; newly hatched forms are fed and cared for in special nurseries, as also the king and queen in the royal cell where they remain.

Observation reveals faecal feeding. The extruded pellets are eagerly seized and fluid droplets from the rectum are even more quickly taken, even to the extent of draining the intestine of its fluid contents. This protodeal feeding is supplemented by stomadeal feeding by means of regurgitated fluid. When a termite wishes food it strokes the body of another individual with its antennae, and the specimen thus caressed exudes from the posterior or from the anterior end of the body a drop of matter which is eaten by the hungry one. The matter exuded from the posterior part of the body appears to be very different from that yielded by the mouth, so that there are at least two kinds of this secreted food. The protodeal food is in great favour with adult termites, but so far as can be gathered it is not used for feeding the newly born young, which are believed to be fed on matter elaborated in the bodies of adult workers and transferred by the mouth. Termites also have the habit of eating their cast skins and even their dead companions, and in fact their system of keeping their nest clean seems to be that of eating the refuse of their own bodies till it no longer contains any vegetable matter.

Fungus gardens

The species of termite under consideration cultivate what are termed fungus gardens in special chambers in the nest or termitarium. These gardens are spongy in appearance, very light in weight, and consist of regurgitated soil full of mycelium of the fungus, which can be seen as tiny white globules scattered all over the surface and cavities of the sponge-like material. In an old termitarium these gardens may be very numerous and of varying size and shape, according to the species. In a termitarium recently opened (8 ft. 3 in. by 6 ft. 2 in. by 5 ft., or 254.4 cubic feet), 543 fungus gardens were present; approximately two per cubic foot. After a spell of rainy weather masses of this comb are often brought up in a triturated condition and deposited on the surface of the soil, from which develop numerous fruiting bodies like toadstools, which agree with the agaric fungus described by Petch as *Entoloma microcarpum*. Little is yet known how the fungus is utilized by the termites and of its significance in the biology of the colony, though it can be readily demonstrated that the immature forms regularly feed upon it. In the nest mentioned above all stages of the various castes, including winged reproductives and eggs, were found in the cavities of each fungus garden, from which it may be deduced that the gardens occupy an important place in the biology of the colony. Whatever may be the influence of these fungus gardens on the life of the colony, it has been the writer's experience that in all cases where the queen and all the fungus gardens have been destroyed this has resulted in complete cessation of activity in the nest and the colony has died out. Whether this will always be the case under all conditions remains to be demonstrated.

Grass and Grazing

What is the part played by the fungus-grower in connexion with grass and grazing? It has been shown above that the workers are cellulose feeders and will take to devouring wood when it comes their way as naturally as a duck takes to water. However, it has to be admitted that there are vast areas within this Colony where the termite population is considerable and where trees and shrubs are virtually absent, which leads one to believe that decaying grass is probably their staple cellulose food in many parts of East Africa. In a year of drought such as the one just experienced, when there was little gass cover the runways of of soil ensheathing grass stems and roots became particularly obvious, even to the uninitiated; and the destruction caused by the drought was completed by these termites. At this time many reports were received of golf courses being completely denuded of the grass cover by termites, and indeed such courses were a dreadful sight to behold. On the advent of the rains grass reappeared only on the soil in a high state of fertility; on soil lacking in fertility the grass was replaced by weeds. In the native reserves, where soil erosion and overgrazing are rampant and where harvester termites are reported to be present, the small amount of grass cover is probably further depleted by the fungus-growing termites. While it is more likely that their normal toll is dead or decaying grass and leaves, in the absence

of an abundance of such supplies it seems unavoidable that they should attack the stubble and roots of grass. In years of normal rainfall and on soil with a high fertility these species appear to cause little if any damage, but in years of drought and in overgrazed areas they are strongly suspect. Thus the influence of grazing practice and unfavourable rainfall on the success of these species is a problem worthy of investigation. The removal of grass cover by harvester termites and fungus-growers in overstocked areas leaves little to prevent the rapid run-off of water, and thus drought conditions and soil erosion are aggravated.

Control measures

The popular idea that the removal of the queen will result in the death of the colony is entirely erroneous, and ignores the fact that supplementary reproductives, king and queen, can be developed from certain forms still in the nymph stages, which then take over the reproductive work of the colony. However, as previously mentioned, the removal of the queen together with all the fungus gardens in the termitarium or nest has resulted in complete cessation of activity, and the nest has not been re-formed. According to the writer's personal observation, this is the only method which has resulted in the death of the colony in each instance. No explanation of this result can be given other than that the fungus-gardens are a source of supply of some food material essential to the life of the colony. This point is worthy of further investigation.

"*Universal White Ant Exterminator.*"—This machine consists of a small furnace connected to an air pump by rubber tubing. In the furnace a charcoal fire is made, over which is thrown a mixture of three parts by weight of white arsenic and one part by weight of flowers of sulphur. The lid of the furnace is then clamped tight and with the aid of the pump the hot fumes are pumped into one of the large galleries leading down to the nest. If the opening to one of the large galleries is not visible on the surface, the nest should be opened until one is found, as it is no use pumping the gas into the small galleries. The operation should last for fifteen to twenty minutes, and then all the openings should be plugged with wet earth. The machine, which has given excellent results, though it is not always successful, can be purchased in Nairobi for Sh. 135. In practice it may be found necessary to treat a nest more than once.

Cyanide fumigation.—This method consists of pumping calcium cyanide powder into the nest in a manner similar to the above. The powder, on coming into contact with moisture in the nest, gives off hydrocyanic acid gas, which is poisonous. The quantity of powder to be used is dependent on the size of the nest, ranging from 3 oz. to 3 lb. per nest; in the latter case, the cost is Sh. 7/50 for materials alone. Fumigation with cyanogas has been found only partially successful.

Carbon-bisulphide fumigation.—A fourth method is fumigation with carbon-bisulphide, a liquid which gives off a heavy gas at temperatures above 70° F. or 21° C. As mentioned above, a large gallery should be found, and from 9 to 13 oz., or one-third to half a pint of carbon-bisulphide poured in. All the openings in the nest must be immediately sealed. Since carbon-bisulphide vapour and air form an explosive mixture, great care should be taken when handling it, and on no account should a naked light or lighted cigarette be brought near. This method of destroying a nest has been found to be more effective during the rains than during the dry season. Termites appear to congregate in the nest during the rains more than at any other time, and this may explain the greater success obtained at this period.

Care should be exercised with all three methods of fumigation mentioned above, since the gases are poisonous, and unnecessary exposure should be avoided.

SUMMARY

The problem of termites and their control is an important one and very complex. It is necessary to determine the species concerned before control measures are advised. Two types of termites, namely harvesters and fungus growers, are here dealt with. The organization of a colony and the nest construction of each type are described. Control measures for each type are given.

A cider man told me of an uncle who "made a thundering good brew; he always wired in the heap of apples and penned the ducks on 'em over two Sundays".

Raymond Bush in *The Countryman.*

Never disregard a book because the author of it is a foolish fellow.

Lord Melbourne.

NOTES ON PLANT DISEASES

NEMATODE DISEASE OF OYSTER NUT

By R. M. Nattrass, B.Sc. Agric. (Lond.), Ph.D. (Lond.), D.I.C., Senior Plant Pathologist, Kenya Department of Agriculture

The cultivation of the oyster nut in Kenya is, as yet, in its infancy, and up to the present no serious pest or disease has been reported. This plant has recently been found, however, to be very susceptible, at any rate in the seedling stage, to attack by the root eelworm, *Heterodera marioni*, which also attacks a large number of wild and cultivated plants in Kenya.

The effect of eelworm attack on most plants is, as is well known, the formation of a number of small galls or swellings of varying sizes on the roots. On the oyster nut, in all instances examined, the effect of the eelworm has been to induce the formation of a single large swelling on the main root just below soil level (Fig. 1). These vary in size according to the stage of development; the largest yet seen was about $2\frac{1}{2}$ in. in length and 2 in. in diameter. At first the surface of the swelling is more or less smooth, but later the external tissue becomes spongy, and is invaded by various fungi and free-living soil nematodes.

FIG. 1—Young plant of Oyster Nut, showing advanced stage of eelworm attack. × 4/5ths (approx.).

Where the oyster-nut nursery is established in gardens, the plants are very liable to eelworm attack, as it is in such situations, where susceptible plants are often grown continuously, that the soil is likely to become heavily contaminated with eelworms. No nurseries should be started on land where eelworms are to be found. The presence of eelworm can usually be ascertained by an examination of the roots of plants, especially perennials, already growing there.

Young plants which show any sign of eelworm attack or any suspicious swellings on the roots should, of course, not be planted out, as there would be a grave danger of the soil in the permanent plantation becoming contaminated and rendering subsequent cultivation of the crop precarious. For the same reason it is unwise to purchase plants from an outside source as these may also be already infected or carry with them contaminated soil. It is recommended that plants are raised well away from gardens on land which is known to be free from eelworms or else in sterilized pots containing sterilized soil.

IMPRESSIONS OF THE COFFEE-GROWING IN EAST AND CENTRAL AFRICA–II*

By Dr. Hille Ris Lambers

Now I will say something as to selection in general. It struck me that on most experiment stations a good deal was being done for the improvement of the technique of vegetative propagation, especially by means of cuttings. Opinions as to the value of this were, however, pretty widely divergent. At Lyamungu much good was expected for Arabica from grafts, though this had not yet become commercially practicable. At Amani approximately pure lines of Arabica were being grown through several generations, and in addition crosses were being made between different species.

At Nairobi I visited an estate where in the older plantations rejuvenation was being undertaken by means of top-grafting. I was much struck by the fact that the old stems below the site of the graft were sawn obliquely downwards at an angle of about 45 degrees and then the surface of the wound was covered with a black tarry mass. To my question why this additional work was so carefully done, I received the answer that, when the old stump remained as it was, severe dieback set in as far as the root collar and even lower. Later I visited at the experimental station, the so-called "Chamber of Horrors", where Mr. Jackson, who deals especially with questions of vegetative propagation, had exhibited a great number of stumped trees that had been cut down the middle. These trees were not sawn obliquely after the stumping; the dieback of the old stem was very deep, down below the point of attachment of the shoot, whether grafted or not. In many cases the young growth was fed only by means of a narrow segment of healthy wood with bark. Alongside them stood a number of stumped trees, the old stems of which had been sawn off at an angle of about 45 degrees obliquely downwards, after which the wound-surface had been smeared with a certain protective substance. The dieback was here very superficial, while the wound-surface was covering itself from the edges with a solid callus. As protective substance "Shelmac" was being used, about 80 per cent asphalt with about 20 per cent of a solvent consisting of the so-called "White Oil", one of the hydro-carbons comparable with paraffin, but very poisonous. This mixture, which remains soft and plastic and is proof against wind and weather, appears however not to be poisonous.

In general, stumping is recommended just before the trees begin a new growing period, that is, shortly before the beginning of the rainy season, when the sap-flow may not be inactive but it has not become strong. The stumping must be done above an already existing off-shoot. If none is present the repercussion on the root system is much greater, for the feeding process is suspended for a time, while in the other case the flow of sap can immediately proceed, at least in part, through the new shoot. The recommended method of stumping, which I afterwards saw practised also in the Belgian Congo, is to remove the crown from the tree to be stumped except a few branches. These branches remain to feed the root system and shade the young shoot, which in consequence of the stimulus given by the removal of the greater part of the crown, comes into existence in the face of severe insolation and fluctuations in temperature. When the shoots are strong enough they are successively removed, after which the tree is stumped in the manner described above[1]. If drastic stumping has been done without waiting for the shoot, then the piece of stem above the shoot that is to be retained must be carefully sawn off. A horizontal cut is discouraged. On the basis of what I have seen I can support the methods just explained. Even if in most Java coffee plantations there is no trouble with dieback—the safe way is to be preferred.

I saw a very interesting method of selection practised in the neighbourhood of Kampala. Originally much wild Robusta appears to have been planted here, obtained in the forest by the natives, either as young plants or as cuttings, and planted in their gardens. Formerly only a few trees were planted for personal use, the coffee was not roasted and the infusion drunk, but the berries were picked hard and unripe, to be boiled and chewed, the bean in parchment being spat out and the boiled pulp eaten. I happened to find a heap of such boiled green coffee on a mat in a garden, so I made use of the opportunity to try Robusta coffee for once in the Uganda style. The taste reminded me of unripe rye grains. I gathered that this coffee was intended for the native market.

* Continued from July, 1940 issue (Vol. VI—No. 1).

[1] The branches of the crown are removed and then the main stem at a point immediately above the uppermost shoot to be retained.—L.R.D.

In this same garden the Government botanist had selected two mother trees, the seed of which was collected and used for starting new plantations. I photographed one tree that had a diameter of sixteen feet, made up of a group of four stems, which at the beginning had bent out and had formed different generations of new stems which bent of their own accord. The whole tree in this way consisted almost exclusively of primary wood. Types were selected that gave easily bending stems.

In many cases these trees were what we call Uganda type, but average Robustas also occurred.[1] I have not come across what we call *canephora,* trees with a comparatively oval smooth leaf and berries that when young are bronze or chocolate brown, nor the Quillou type. I did find these forms in the Belgian Congo, especially in the Yangambi plantation, where I also found forms, known locally as *C. canephora* var. *quillouensis*, which resembled Quillou in habit of growth but *canephora* in the bronze colour of the berries. These sowings came from material that had been found wild.

At Mulungu, Kivu, the main attention is given to generative selection (i.e. selection of lines sexually reproduced) and the breeding of lines resistant to the *brûlure* already mentioned.

On the basis of the results obtained up till now, but small prospects are seen for artificial cross-breeding. At Yangambi, where a good deal of Robusta selection was done, cross-breeding was just being started. This was carried on by enclosing branches in mosquito-netting, but use was also made of grafts of different clones, which were planted in big boxes and shortly before the flowering were brought to the primary forest, both to get self-pollinated seed and to get certain crosses, for which two grafts of different clones are put alongside one another. It is claimed that self-fertility is generally greater there than we (in Java) have been able to show in Robusta clones[2]. This can, however, only be decided with controlled self-pollination under mosquito-netting on clones already studied. Naturally, this may also depend on the material. For practical purposes an attempt is made to get a good deal of seed by keeping about 15 per cent of the best trees in certain good mother-tree progenies and cutting the rest down. These 15 per cent can fertilize each other; the seed thus obtained is used for plantation purposes.

Although it certainly is possible that in this way even and good-cropping progeny can be obtained, I am of the opinion that controlled artificial fertilizing of these 15 per cent among themselves must in the long run lead to the discovery of really superior combinations. So far as Arabica material is concerned, the different coffee gardens provide seedlings brought together from all possible coffee producing countries. From this the attempt is made to isolate production lines for certain areas and in addition much attention is devoted to the selection of the best imported material that is considered to be more or less adapted to local conditions. In particular much work is being done in the Congo nowadays on the testing of the different Robusta-like forms found wild. The *excelsa* group receives much less attention, while the interest in *congensis* is very small. This is doubtless connected with the fact that in the Congo not much is thought of coffee clones.

It has astonished me how uniform the seedlings often were from wild Robusta-type trees, that I met with in the experimental plots. No attempts at all have, however, been made to follow up with the mother trees the question of how far fruit-setting and self-fertilization is possible among them. Also I have nowhere met with grafts from such wild trees, only seedlings.

Besides Robusta and Excelsa types, many other species of coffee occur in Central Africa, among which I shall mention *C. eugenoides* first. I met with it wild in Kenya, Uganda and Kivu, as well as in northern Belgian Congo. It is noteworthy that this species can vary widely even in the same locality, so that in a comparatively small area I was able to collect quite four or five distinctly different types. Later I came across a 2-hectare plantation of this species at the Nioka Experimental Station, with about 4,000 plants to the hectare. This seed was collected from a group of sixteen trees, raised from mixed seed out of the forest. In this plantation the wide variation was even more clearly obvious than in the forest, since the plantation was laid out on a flat area entirely without shade. The little trees exhibited a rather thick-set habit of growth compared with forest plants, which in consequence of the small amount of light generally grow tall and lank. Shape and size of the leaves, set of the branches, shape and size of the berry were extremely different, as appears most plainly

[1] In our experience the type called "Uganda" by Java workers does not produce the pliable stems that are a feature of the "Nganda" type, described by Thomas and well known in East Africa under that name.—L.R.D.

[2] It is possible that the discrepancy is due to the method of isolation adopted. Mosquito-netting cages do not seem to be completely effective in excluding foreign pollen.—L.R.D.

both in photographs and in herbarium material I collected. In some cases I met with plants wholly resembling miniature Arabica. It is therefore not to be wondered at that in some cases material of *C. eugenoides,* sent to Europe for determination, came back as *C. arabica.*

As you know, Abyssinia passes for the homeland of *C. arabica.* I am not aware, however, that this species is found wild there in the same way as *C. eugenoides,* but it seems to me not impossible that originally *C. arabica* and *C. eugenoides* had something to do with each other. In that connexion it would be very interesting to know how far the range of truly wild Arabica extends and how far this area goes in relation to *C. eugenoides.* Of the latter, however, the range westwards is not yet known nor the eastward extension of *C. congensis.* This occurs in the Congo basin, and I have seen two very different forms of it, one of them closely resembling certain forms of *C. eugenoides.* Conversely I found in the sixteen *C. eugenoides* mother trees a strong likeness to *C. congensis* so far as berry, tree shape and leaf shape were concerned.

My theory, at present based on insufficient facts, is that a recent connexion exists between *C. eugenoides* and *C. arabica* in an easterly direction and between *C. eugenoides* and *C. congensis* in a westerly. I do not mean to say by this that *C. arabica* and *C. congensis* have arisen from *C. eugenoides,* but that perhaps they are to be referred to the same ancestral form. To what extent natural crossing has played a part in this connexion must be left quite undecided, but it is very probable that it has contributed to the appearance of the coffee species at present recognized. In one case I found in a patch of forest some plants of wild Robusta only a few hundred yards from some of *C. eugenoides.* I collected seed of both species, to find out, among other things, whether in one of the two sowings some crosses might occur. The plants are still young, but already I can say that some of the *C. eugenoides* seedlings have much more robust leaves than seedlings of the same species from other localities. With this sowing the number of vegetative abnormalities was notably high in both species.

I have already mentioned that I had an opportunity of inspecting a 2-hectare plantation of *C. eugenoides* at Nioka. The plan is to extend plantings of this species to see how far it is economic, in view of the fact that the report on samples sent to Europe was very gratifying.[1] On viewing sowings from separate mother trees of Robusta type, which I saw especially at Yangambi (i.e. in the Congo), it struck me that few type varieties were present within a sowing, but that the differences between the sowings were often very great.

The botanists in the Congo are generally in agreement with the views of Chevalier, who accepts one main species, *C. canephora,* of which other species of Robusta type are only local varieties. Also there is doubt whether *C. liberica* and *C. excelsa* should be regarded as separate species. This certainly looks like an easy solution of the difficulties, but in my opinion it is an ostrich policy. Only systematic collecting and planting of wild seed and a very accurate mapping of the ranges of the different species or forms could bring nearer to solution this question, which is of an importance not purely scientific.

You will perhaps be interested to hear how, travelling through the Congo by car, I was able to find wild coffee. This is not so easy. Various attempts I made to enter the primary forest at arbitrary points and to look around for wild coffee had no result. I certainly found a great number of Rubiaceae that were without doubt nearly related and bore a deceptive resemblance to coffee, but when flowers or fruit are lacking it is impossible to identify them with certainty. We had more success when we asked in a native village on the forest edge whether they knew of wild coffee trees. In some cases our troubles were rewarded, after a long tramp over difficult ground, when our guide suddenly stopped at a little tree and declared that it was coffee. It was even then not easy to make out whether the man was right or not, for the branches with leaves and fruit were so high above the ground. Self-sown seedlings (*kepellans*), to which I always paid attention, seldom occurred. The spreading of seed from isolated wild coffee trees thus appears not to be so simple. With *C. eugenoides* the conditions for the germination of seed appear to be more favourable; at any rate, with this species I have several times found young plants under the trees. Under trees of the so-called *C. brevipes,* a species completely unknown to me, with big berries, of which in nature I never met with more than two in a fruit cluster, I found young plants too. This species occurs, like *C. eugenoides,* in groups. It has so far not been introduced to Java, but at Yangambi I came across a few very young examples in the experimental plots.

Trials, which we are now instituting here, should show what value all these coffee species possess and what is to be attained by means of crossing and further selection.

[1] This is in contradiction to the verdict on *C. eugenoides* from Kenya.—L.R.D.

GRASSES AS INDICATOR PLANTS IN UGANDA—II*

By A. S. Thomas, B.Sc. (Hort.) (Lond.), M.Sc. (Reading), A.I.C.T.A.,
Department of Agriculture, Uganda

(*Received for publication on 23rd March,* 1940)

Cymbopogon Afronardus

This species is cited as representative of the plants which grow on the poorer soils of the areas which climatically are suited to Elephant grass. It forms large tufts of glaucous leaves (they show up at night in the headlights of a car even more vividly than by day), and the flowers are borne or yellowish stems four or five feet high. The tufted habit enables the grass to resist burning, while the leaves are distasteful to stock because they are so aromatic; for the same reason they are spread on the floors of African huts to repel insects. *Cymbopogon Afronardus* is found in two habitats: on patches of poor soil on the hillsides and on the infertile grey soil of swampy hollows. It is evident that its occurrence in both situations is due to soil poverty, for neither is suited to Elephant grass. On good soil the latter can displace the *Cymbopogon* by virtue of its greater height and more vigorous root system.

Loudetia kagerensis C.E. Hubbard ex Hutch.

On the headlands which project into Lake Victoria and on the Sese Islands, the vegetation forms a striking pattern of sharply defined patches of dark forest and large stretches of short yellowish grassland. In this grassland *Loudetia kagerensis* is the dominant species, with little admixture of any other flowering plants. The rainfall is well distributed throughout the year, and on the Sese Islands the total amount is higher than in any other district of the Protectorate—it may be 80 inches or more per annum—and therefore is well suited to the growth of closed forest. The influence of burning or grazing cannot be blamed for the persistence of open grassland in this area, for the Sese Islands were evacuated for about twelve years on account of sleeping sickness, and the sites of former farms became covered with a dense secondary forest, yet the trees encroached very little on the grassland; although hippopotami and sititunga were plentiful in the islands, yet they could not graze down such large areas of grass.

The Sese Islands closely resemble the north of the Bukoba district of Tanganyika; the rainfall, the soil and the natural flora are all very similar; there is the same thin, short cover of *Loudetia kagerensis* over most of the countryside, but whereas in Sese some of the better land is cultivated and some is under secondary forest, in Bukoba practically all the land on which forest might grow is occupied by farms. Milne [1] has shown the extreme poverty of the grassland soil in Bukoba, and analyses by the chemical section in Uganda have proved that the Sese soils are similar; that *Loudetia kagerensis* is dominant over such large areas because the ground is too poor for other plants to flourish. Native tradition, supported by photographs, states that the trees are spreading very slowly into the grassland in two habitats: firstly, at the seepage level near the shores of the lake, and secondly around the base of large anthills. It is not surprising that new tree growth should commence in such places, where one would expect to find an accumulation of bases and other plant nutrients. The vegetation of the islands differs from that of the mainland in many interesting particulars, all of which indicate the poverty of the soil. For example, there is an abundance of ferns on the outskirts of the Sese forests, while many plants—for example, Elephant grass and Star grass (*Cynodon*)—which are found in abundance on good soils on the mainland are very rare on the islands.

In association with *Loudetia kagerensis* are other grasses which are indicative of very poor soil. On rocky outcrops there is the tufted *Eragrostis blepharoglumis* K. Schum., and in the moister spots there is the creeping *Eragrostis Mildbraedii* Pilg. In fact, the persistence of any member of the two genera (*Loudetia* and *Eragrostis*) in any part of Uganda usually seems to indicate soil poverty. *Loudetia kagerensis* is not confined to the shores of Lake Victoria; it is locally dominant on patches of sandy soil in Ankole, where the rainfall is much less than on the Sese Islands. Wherever this species is abundant, the soil is very poor.

Cynodon species

Three species of *Cynodon* have been recorded from Uganda: the small introduced *C. transvaalensis* B. Davy, locally known as

* Continued from July, 1940, issue (Vol. VI—No. 1).

Masindi grass; *C. Dactylon* Pers., French grass or Dhoob grass, and *C. plectostachyum* Pilg., Star grass. As mentioned earlier in this paper, there is such a diversity of forms that all three species seem to grade one into the other, and, as there is much resemblance between their requirements, they may all be discussed together.

In Uganda, the *Cynodon* species all flourish in heavily manured soil. The Luganda name for Star grass, *Karandalugo,* means "by the cattle kraal. They seem to be especially responsive to the amount of nitrates in the soil. On account of their spreading habit, Masindi grass and French grass are commonly used as lawn grasses in this country. When first planted they often grow rapidly and soon form a cover, but after a few years their vigour diminishes and they are replaced by other coarser grasses. On an old lawn, unless it has been carefully weeded and manured, little *Cynodon* may be seen, but a dressing of ammonium sulphate on such a lawn often produces a remarkable reappearance of the *Cynodon;* it seems to respond more rapidly to the manure than does any other species.

In the wetter parts of Uganda, *Cynodon* occurs little in natural grassland, but it is abundant as a weed of cultivation, near dwellings and kraals. On the poor soils of Sese no *Cynodon* has been found except for a single patch on an old kraal site. *Cynodon* also is a plant typical of the sides of paths and roads, persisting on the compact soil of pathways and growing luxuriantly on the disturbed soil of banks and ditches, yet being absent from natural grassland a few yards away. This occurrence of *Cynodon* is an illustration of the false impression of Africa which may be obtained by travelling only along main roads. In Britain the special plant communities of roadsides and pathways have been attributed by Bates [2] to physical factors, but as the *Cynodon* spp. seem so dependent on a good supply of nitrogen it appears that in Uganda chemical factors also are involved, as suggested by Davies [3]. It would be expected that there would be a manurial effect on paths frequented by stock, and in addition to the *Cynodon* spp. there are other typical roadside grasses (for example, *Brachiaria* spp., which are indicative of good soils.

Cynodon plectostachyum is not one of the main pasture grasses nor is it relished by stock in the wetter parts, but the drier the conditions the more important does it become in Uganda. In the north and east it is a very important pasture grass, and is readily consumed by stock. The relative abundance appears to be due, in part at least, to chemical factors; the nitrates accumulate in grassland to a greater degree where the rainfall is sparse than in wetter areas. As mentioned above, in dry grasslands *Cynodon* is especially valuable on account of its ability to colonize kraal sites and pathways which are infertile to other plants. Whatever may be the cause of infertility—physical compaction or chemical composition or a combination of the two—it is of great importance that there is one species which will grow under such conditions and help to control erosion.

Digitaria scalarum Chiov.

(*Luganda*: Lumbugu)

This grass spreads by underground runners like those of the "couch" grass of Britain, and as its growth is very rapid the control of this species is a factor of major importance to agriculture in the cooler, moister parts of Uganda. Many acres of coffee have been abandoned when they become badly infested with this weed.

Digitaria scalarum is relished by cattle, and when heavily grazed it forms a close cover over the ground, but it is not a constituent of natural grassland in most parts of Uganda; its presence almost always denotes that there has been cultivation at some time. Once it has become established it will persist for many years, whether it is grazed or whether it is shaded by a close cover of Elephant grass. A long ley of Elephant grass, in addition to restoring soil fertility, does reduce the amount of *Lumbugu,* and therefore is of value in assisting control of the pest. As a weed of cultivation *Digitaria scalarum* is most abundant on good soils. On poor or waterlogged soils it is often replaced by *Eragrostis Mildbraedii,* another "couch" grass. It is most important as a weed in areas with a well-distributed rainfall lying between altitudes of about 7,000 ft. (the upper limit of cultivation) and 3,500 ft.; in Bwamba, at an altitude of 3,000 ft., it does not grow so vigorously as in Toro, at an altitude of 5,000 ft., although both areas enjoy a heavy rainfall.

On the north side of Mount Elgon, at an altitude of about 9,000 ft. to 9,500 ft., are extensive pastures, heavily grazed by the cattle of the pastoral tribe (locally known as Wanderobo) who live there. These pastures have been formed by continuous heavy grazing of the mountain grassland and scrub, and consist

of a close sward of *Digitaria scalarum* mixed with a purple clover (*Trifolium cryptopodium* Steud.). On account of the altitude and the grazing, the *Digitaria* is much smaller than when it is growing as a weed of cultivation at lower elevations; the small form has been called a distinct variety (*Digitaria scalarum* var. *elgonensis*), but when it was planted at Kampala it grew as large as the common *Lumbugu*. In no other part of Uganda but Mount Elgon has *Digitaria scalarum* been observed in abundance on undisturbed soil, but only as a weed of cultivation; therefore it seems highly probable that its wide distribution is due to the influence of man, whose cultivation has enabled this grass to extend its range from its original home on the mountains.

Pennisetum clandestinum Hochst.
(*Kikuyu grass*)

The distribution of Kikuyu grass in Kenya has been discussed by Edwards [4], and the same factors appear to govern its growth in Uganda. In this country also it may be regarded as the first stage in retrogression from mountain forests. Just as the *Cynodon* spp. are indicators of high fertility at low elevations, so also is Kikuyu grass an indicator of high fertility at altitudes from about 6,000 ft. upwards. The soils of some Uganda mountains do not seem to be naturally rich enough to support the growth of *Pennisetum clandestinum*. The grass is abundant on the fertile soils of the volcanic mountains (Mount Elgon and the Muhavura Mountains in Kigezi), but has not been recorded in the wild state from Mount Ruwenzori, a mass of the Basement Complex, on which the soils are relatively poor. Grazing may be an even more important factor in the distribution of Kikuyu grass, for until recently there has been little live stock on Mount Ruwenzori, although cattle have been kept for a long time on Mount Elgon and in Kigezi. When Kikuyu grass pastures are not grazed or cultivated they often rapidly revert to scrub and then to forest.

The most striking development of Kikuyu grass in Uganda is to be seen in the pastures of Mount Elgon, at an altitude of 6,000 ft. to 6,500 ft., and in Kigezi at about the same altitude. In both localities it is associated with several different *Trifolium* spp. and is subjected to heavy grazing. It has been found growing naturally outside these areas, but only on kraal sites. Small patches have been seen in such spots in the high mountain pastures of Mount Elgon (at 10,500 ft.) and on Mounts Kadam and Moroto in Karamoja, to the north of Mount Elgon. Nutrition seems to be more important than temperature in controlling the growth of this species, for in moist areas as low as 4,000 ft. it will grow quite well if it is heavily manured; but, as mentioned above, the main factor governing the distribution of Kikuyu grass appears to be the presence of stock.

Discussion

An attempt has been made to demonstrate that the grasses well repay study as indicator plants, but that account must be taken of all the factors which influence their growth: climate, soil and the effect of clearing, cultivating, burning and grazing. It appears that in Uganda the influence of man and of stock has greatly extended the range of some of the more important grasses. Until more is known about the interaction of all the factors, it seems to be a mistake to apply definite ecological terms to the plant communities of African grasslands. The appearance of any one piece of grassland may vary so much according to the degree of grazing and the season of the year, that great caution should be used in endeavouring to state the composition in mathematical terms. Agreement has not been reached concerning the best technique of pasture analysis [5], and the human factor may vitiate direct comparison of the results obtained [6]. Care must be exercised in making even general statements. It is probable that some of the suggestions in this paper will conflict with the observataions of other people in East African territories, and it is hoped that they will point out any differences of opinion.

A study of the occurrence and behaviour of grasses in the wild state is of great value in showing their requirements when they are cultivated. One important general rule is evident, that many of the more useful grasses—for example, Elephant grass, Star grass and Kikuyu grass—require good soil if they are to flourish. If we are to use grass leys to restore fertility to our soils, it is important that the land should revert to grass before it is too impoverished, or we shall not be able to establish the good grasses. This rule is evident from the succession of grasses on poor, abandoned land: first come the ephemeral grasses, then the poorer perennial grasses, and finally the good perennial grasses. The worse the soil, the longer the period before the good grasses become abundant; if the soil is very bad, they may not come in at all. Soil fertility often

seems more important than climate in controlling the growth of grasses; for example, Elephant grass persists and grows vigorously on good soil in the highlands of Kenya, where conditions are too cool for it to flower; but the grass will not grow if planted in the grassland soils of Sese and Bukoba, where the climate is admirably suited to this species, as shown by its vigour on good farm soils in these districts.

Finally, mention may be made of the question of leguminous plants for inclusion in pastures. On the mountains, above about 6,000 ft., native clovers (*Trifolium* spp.) are often abundant, and are valuable constituents of pastures. But in the more tropical grasslands of Uganda, covering a wide range of types, no very useful leguminous grazing plants have yet been seen. Those which have persisted (for example, species of *Crotalaria* and *Indigofera*) appear to be distasteful to stock, and many members of these genera are poisonous. The flora of Uganda is rich in leguminous plants. The number of species recorded is about four hundred and fifty—the same as the grasses—but apart from the clovers none of the herbaceous species seem to be of much value for grazing, although some of the woody ones are useful browse plants in dry areas.

Up to date, no introduced pasture legumes have been of value, all dying out soon. One interesting exception is wild white clover (*Trifolium repens* L.), near the old fort at Kampala, where the British flag was first unfurled in East Africa. When and how the clover was introduced is not known, and attempts to establish it elsewhere have been unsuccessful; it is only in this one place that it has persisted. It may be that valuable legumes will be obtained sometime in the future, but until then we should make the best possible use of the grasses.

Summary

It is suggested that the grasses are a most valuable group to utilize as indicator plants; but it is essential that due allowance be made for the effects of season and of grazing in altering the appearance of grasslands; casual observations may be misleading.

The distribution and habits of six Uganda grasses are described, and an attempt is made to show the interaction of the factors—climate, soil, and the influence of man and stock—which control their growth. The range of any species may be dependent largely upon burning, grazing or cultivation.

It is pointed out that, as a rule, the best grasses grow on the best soils, and that if grass leys are to be used to restore soil fertility the grass should be planted before the soil is too impoverished.

REFERENCES

[1] Milne, G.—"Essays in Applied Pedology, III, Bukoba: High and Low Fertility on a Laterised Soil," *E.A.A.J.*, Vol. IV, p. 13; 1938.

[2] Bates, G. H.—"The Vegetation of Footpaths, Sidewalks, Cart Tracks and Gateways," *Journal of Ecology*, Vol. XXIII, p. 470; 1935.

[3] Davies, W.—"Vegetation of Grass Verges and other excessively trodden habitats," *Journal of Ecology*, Vol. XXVI, p. 38; 1938.

[4] Edwards, D. C.—"The Grasslands of Kenya, I," *Empire Journal of Experimental Agriculture*, Vol. III, p. 153; 1935.

[5] Davies, W., *et al.*—"Methods of Pasture Analysis," *Agricultural Progress*, Vol. X, 1933.

[6] West, O.—"The Significance of Percentage Area Determinations," *Journal of Ecology*, Vol. XXVI, p. 210; 1938.

CORRIGENDA TO PART I

This Journal, Vol. VI, No. 1, pp. 19–22.

Page 20, column 2, line 14 from bottom: For "*Setaria* sp" substitute "*Setaria incrassata* (Hochst.) Hack.".

Page 20, column 2, line 3 from bottom: For "*Aristida* sp." substitute "*Aristida* spp.".

Page 21, column 1, line 2: For "*Euphorbia* sp.. *Aloe* sp., *Sansevieria* sp." substitute "*Euphorbia* spp., *Aloe* spp., *Sansevieria* spp.".

Page 21, column 1, line 17: For "*Commiphora* sp., *Acacia* sp." *substitute* "*Commiphora* spp., *Acacia* spp.".

Page 21, column 2, line 28: For "*Poa* sp., *Festuca* sp" substitute "*Poa* spp., *Festuca* spp.".

Page 22, column 1, line 12 from bottom: For "*Combretum* sp." substitute "*Combretum* spp.".

A HOME-MADE COW STANCHION

By Major R. R. Sharp, Whinburn, Redbank

(*Reprinted from the* Rhodesia Agricultural Journal, *Vol.* XXXVII, *No.* 3)

It is, I suppose, the ambition of most dairy farmers to equip their cow-byres with stanchions, but the cost of the purchased article is usually prohibitive.

The writer faced with this problem has recently devised a home-made stanchion, which can be turned out in the farm workshop at the cost of some five or six shillings. The stanchion, which is shown in the accompanying diagram, is made chiefly of 1 inch piping. Black piping is preferable, as it is easier to bend and screw; the difficulty of cracking the bends can be overcome if desired by bends or elbows; these, however, slightly increase the cost and, of course, weaken the structure at the points where the pipe is screwed.

The stanchion consists of two pieces of inch pipe hinged at the bottom. The longer piece is bent at each end and is suspended by a swivel joint from a heavy wooden rail running the length of the byre, 4 feet 6 inches or 5 feet above the floor, and attached at the bottom by another swivel and a few links of light chain to an anchor embedded in the concrete curb forming the front of the manger.

The difficulty in bending the pipes arises from the fact that very short bends have to be made and the pipe is liable to distortion in the process. This can be obviated to some extent by filling the pipe first with sand. The bend is then made in the fork of a tree or other convenient place without heating the metal. The necessary leverage can be obtained by inserting the end of the 1 inch pipe into a length of 1¼ inch pipe. The pipe is then gradually bent, moving it an inch or so at a time in order to distribute the bend over the whole of the available length. Finally, the sand, which has been well rammed into the pipe, can be shaken out.

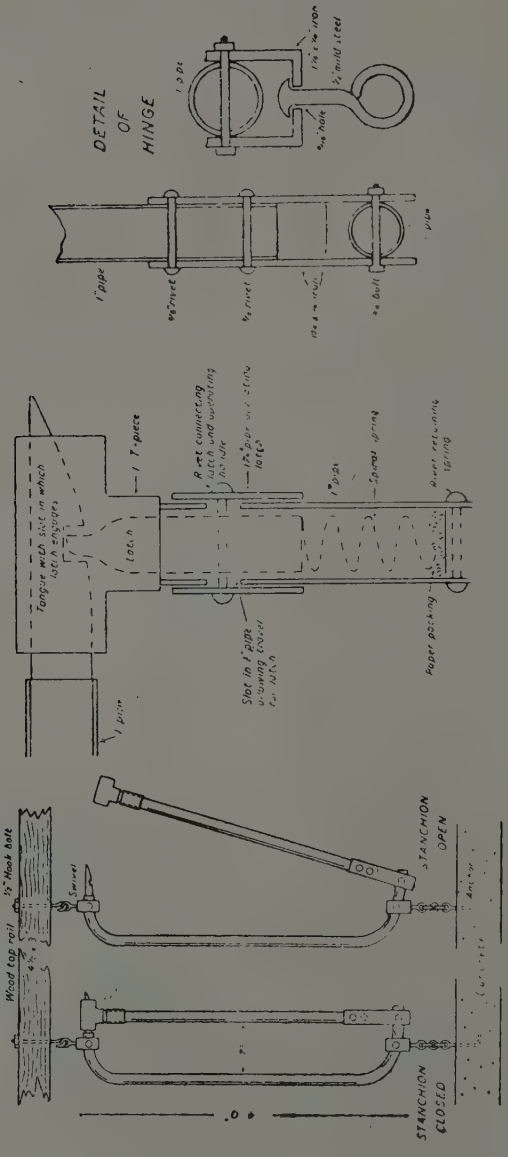
The bent portion of the stanchion carries a tongue inserted in its end, which can be made of a short length of ¾ inch steam pipe, forged to shape. This tongue has a recess to receive the latch when the apparatus is locked; this recess can be cut with a hack saw, and is about ⅜ inch wide and ⅜ inch deep. The latch itself is made of a short length of heavy ½ inch pipe flattened at one end and filed up to present a smooth surface to engage with the tongue. It is held up to its work by a spiral spring contained in the vertical 1 inch pipe, and is operated by a sleeve of 1¼ or 1½ inch piping, which must be free to move easily outside the 1 inch pipe. Sleeve and latch are connected by a ¼ inch rivet passing through both. The necessary travel is given by cutting a slot longitudinally in each side of the 1 inch pipe. Thus when the outer sleeve is grasped and pulled downwards, the spring is compressed and the latch withdrawn, allowing the tongue to be withdrawn from the 1 inch T in which it is enclosed in the locked position. The ordinary 1 inch T pipe fitting is screwed on to the top of the straight or swinging arm of the stanchion and gives rigidity to the whole when locked.

The main hinge is made of two pieces of 1¼ × ¼ flat iron riveted to the straight pipe and the pivot is a straight ⅜ bolt passing through both pieces and also the end of the curved pipe. The swivels are made of short pieces of 1¼ × ¼ inch iron bent into a U shape and drilled to take attachments of ½ inch mild steel, which form the top and bottom fastenings.

The spiral springs should be fairly light; old Ford valve springs are excellent. The rivet which holds up the spring at the bottom should be placed about ½ inch too low. Packing of paper can then be placed above it and rammed down, until the spring has the required tension.

The stanchion can be made by anybody with the help of ordinary farms tools, drill, forge, vice, etc.

The first six which I made have been in use for over six months and have given complete satisfaction. It is thought that other farmers may be interested in this economical way of modernizing the cow-byre.


DETAIL OF HINGE
1 pipe
Tongue with slot in which hook engages
1 T-piece
Hook
Slot in 1" pipe allowing bracket to move
Wood top rail
½" Hook bolt
Swivel
STANCHION OPEN
STANCHION CLOSED

NOTES ON LAND TENURE
I—TRANSKEI AND CISKEI

By V. Liversage, B.Sc. (Lond,), M.S. (Wis.), N.D.A., Agricultural Economist, Kenya

(*Received for publication 13th May,* 1940)

General background

In these territories native agriculture is under the care of the Native Administration, supported by agricultural and other technical services. The natives are mainly pastoral, but engage in crop husbandry as well. The commonest size of arable holding is about 10 acres, and the chief crops grown are maize, beans and pumpkins. The topography varies between rolling and hilly, and the annual rainfall is from 25 inches to 35 inches, falling mainly in the summer (October to March). The country is practically treeless except for plantations which are now being made under Government control. Agriculture is carried on almost entirely for subsistence, cash income being obtained by outside labour. The stage of hoe cultivation has long since passed. Ploughing and cultivating are done by oxen—usually six to a team, with a single-furrow plough—and this work falls to the men. When it is finished and the crops are planted, many of the men go away to work, and the subsequent operations are carried out by the women. Shifting cultivation cannot be practised to any great extent because of the pressure of population on the land. According to local custom, the arable lands are thrown open after harvest for common grazing on the maize stover, etc. A certain amount of manure thus finds its way on to the arable land, but the amount is not large, and fertility is declining. Dung is widely used for household fuel. Marked gully erosion can be seen on much of the arable land.

Live stock

Live stock includes cattle of a small, poor type, sheep and goats, with a few horses and donkeys. In the Transkei the number of cattle has increased from 535,000 in 1918 to 1,368,000 now. Sheep also have increased, though to a relatively moderate extent, while goats have declined. The latter, though used for ceremonial purposes, do not appear to have the same social importance as in East Africa. In the past, Merino rams have been distributed, and the present sheep stocks are grade merinos, yielding 3 to 4 lb. of wool annually. They are a source of embarrassment to the authorities, for a reason which will appear.

Overstocking is prevalent. In the Transkei it is estimated that the number of stock on the grazing land is as much as 80 per cent above that which the land is capable of carrying year in and year out without detriment to the veldt.

In consequence, the pasture has deteriorated seriously. Certainly denudation has not yet occurred to anything like the extent seen in parts of Kenya. Only a small proportion has actually lost its vegetative cover, but coarse, unpalatable succession grasses have replaced the original "sweet veldt". Gully erosion in the valley bottoms is noticeable. The topography bears the marks of having settled down, geologically, for a long period, and the original dissection of the surface by water action has become smoothed down from the ravine formation of "young" valleys to a smooth rolling topography. Within the last few years, however, denudational forces have broken out into fresh activity. In the bottom of nearly every valley is a new ravine a few feet deep. These ravines are rapidly deepening and cutting back. It is obvious that some recent change in the conditions has taken place which, if continued, would cut up the country to a disastrous extent in a very few decades. All agree that the change responsible is the removal of long grass, giving speed and concentration to the surface run-off. Yet the number of live stock per family is held to be too low. The average number of cattle per family is 6.5 in the Transkei, and apparently about the same in the Ciskei. This is insufficient to provide a plough team and at the same time an adequate supply of milk. Moreover, the distribution is extremely uneven, the stock of some owners running into thousands while the remaining owners have very few each.

Dipping is compulsory. In "council areas" the dips were formerly erected from council funds, but nowadays the cost is covered out of the stock rates referred to below. A dipping supervisor is appointed by the Bunga or General Council to superintend the dipping process. In "released areas" dipping tanks are erected with money allocated out of the Native Trust. For each district a dipping account is maintained and the current cost is covered out of a stock rate levied on each head of cattle kept.

Some improvement of the type of stock is being undertaken. In the past the native sheep have been graded up by Merino rams, supplied by Government at low prices. As regards cattle, it is considered that improvement of stock should not proceed without regard to the conditions under which the cattle will have to live, and accordingly Afrikander bulls are being favoured as against European breeds. Bull camps were experimented with, but were not found successful, and now the usual method is for Government officers to purchase bulls and sell them to native stock-owners at half the initial cost.

Measures of Amelioration

These include—

(*a*) de-stocking;
(*b*) fencing and rotational grazing;
(*c*) mechanical improvements such as contour banking and building of dams.

(*a*) De-stocking raises difficult problems in both principle and execution. The overstocking of the pastures is in conflict with the shortage of cattle per family. Stock limitation might be made to bear more severely on small stock, but merino sheep have been introduced by the administration, and it is embarrassing to have to go back upon their adjurations in the past. Moreover, the annual revenue from sale of wool from Transkei flocks is estimated to average some £300,000, a very important part of the Territory's cash income.

Nevertheless, a beginning is being made, particularly in the Ciskei. A proclamation was issued in 1939 giving the Minister for Native Affairs power to control the numbers of stock depastured in any area. After consultation with stockowners and any persons having authority in an area the Minister may declare any area a "Betterment Area". Thereupon all grazing rights cease. An estimate is made as to the numbers of stock which the area can carry, a stock count is taken and animals in excess of the carrying capacity are culled by an officer appointed by the administration. Small stock may be culled more heavily than large, or *vice versa*. Culled animals must be slaughtered or removed from the area, and no stock may be brought in from outside the area except by special permission.

De-stocking has already commenced in the Ciskei, where the natives have voluntarily accepted the principle. In this they have no doubt been influenced by the fact that Government has agreed to erect boundary fences and fences to divide the grazing area into "camps", out of Trust money. Government also provides water supplies and provides 50 per cent of the cost of block-fencing of arable lands. Stock markets are arranged so that surplus stocks can be disposed of under competititive conditions. Some Government grazing land is even put at the disposal of those intending to sell stock, so that animals may be finished off on good grazing for the last month or two before sale. Cattle fetch attractive prices as compared with Kenya. The general run of steers for beef, no better than those raised in native reserves in Kenya, sell for about £2 apiece, and animals reasonably well finished will make up to £5.

In the Transkei the stockowners have not yet submitted to the inevitable. In three areas de-stocking is to be applied very gradually under compulsion. Government, here as in the Ciskei, is providing fencing out of Native Trust money. Dams are being constructed out of a vote for soil erosion work.

Stock are being culled on merit only, without regard to ownership, though in cases of equal demerit those of the larger owners will be culled first.

It is intended to couple the elimination of surplus cattle with castration of surplus males, both of cattle and goats. In the Transkei the introduction of donkeys is prohibited.

(*b*) The difficulties attendant on any attempt to enclose grazing lands into lots in individual occupation are mentioned below. The alternative which is being adopted is to fence the communal grazing land of a location into several enclosures or "camps", each provided with water supplies. Rotational grazing can then be practised, and each camp can be left in its turn for seeding to take place. One camp, also, is set aside for finishing cattle intended for slaughter. Occasionally eroded arable lands are withdrawn from cultivation and planted with grass for hay, to be made by communal labour.

The cost of fencing is high, as fences are designed for small stock as well as cattle. In one estimate a figure of £78 per mile was mentioned, this probably including wire-netting. Iron posts and droppers are generally used, with 7 strands of barbed wire. According to another estimate, the cost of fencing a location would be approximately £5,000. It cannot be expected that Government will pursue its present practice of providing fencing further than is necessary to demonstrate the

benefits to be obtained. The alternative of using a live fence such as Mexican Sisal for demarcation purposes only, leaving actual control of the stock to be done by herding as at present, is not considered a practical proposition; it is thought that the boundaries would not be respected.

(*c*) The Engineering Department is carrying out a programme of mechanical improvements which at first sight appears ambitious and impressive, but which must take many years to complete. *Donga* formation is being attacked by construction of contour banks and stock dams. The general plan is to divert the water at the head of dongas by contour banks and to combine the objects of slowing up the water flow, conserving water for stock and widening its distribution by constructing dams at intervals down the valleys. In the Transkei four units are employed, each consisting of Diesel Caterpillar tractor, dam scoop, drag, packer and accessories and costing some £4,000. It is claimed that this is the cheapest method of carrying out the work; dam building can be done for about 2½d. per cubic yard, as compared with 4d. or 5d. for ox work.

Dams are usually placed so as to collect from a fairly small catchment area, and no special construction of retaining walls or spillways is undertaken. The work is done out of a vote for soil erosion control and the areas benefited are not directly charged with the cost, which is borne by central funds.

Land Tenure

Prior to the annexation of the territories all land was regarded as vested in the chief in trust for the tribe. Petty chiefs allotted each man a portion of arable land for the use of his household. When the cultivator died or abandoned his plot it reverted theoretically to the chief. In the former case, however, occupation usually devolved upon the successor according to native custom. Usually it appears that the eldest son succeeded. Others would apply to the chief for a fresh allotment. Non-arable land consisted entirely of common grazing.

On annexation the Governor assumed the functions of the paramount chiefs. Sub-chiefs were converted into Government headmen, working under the direction of Native Commissioners. The country was divided into districts, of which there are 27 in the Transkei. Each district was divided again into locations.

Districts may be divided into "unsurveyed" and "surveyed" districts. In the unsurveyed districts the ancient system of tenure is still carried on. Plots of arable land are allotted by the location headmen, though in theory allotments are subject to control by the magistrate. With increase of population more arable lots are being given out, with resulting encroachment on the common pasture and accentuation of the overstocking problem.

In the surveyed districts an attempt was made to replace the ancient system by a form of individual occupation. The system was first applied in Glen Grey, in the Herschel district of the Ciskei, under the influence of Cecil Rhodes. This was in 1894, and subsequently seven of the 27 Transkei districts were surveyed. Individual occupation was applied to the arable land only, and communal grazing was still continued on the pastuure. Arable plots of approximately 4 morgen (8½ acres) were surveyed and granted to natives in perpetuity, subject to certain conditions. One man could receive only one plot; this was indivisible and was to pass by inheritance according to native custom to one heir only; the holding could not be pledged as security for any mortgage or charge, and transfer otherwise than to an heir was subject to the approval of the Chief Magistrate; a perpetual quit-rent of 3/- per morgen, with a minimum of 15/- per plot was payable; the holding could be forfeited by non-cultivation for a period of two years or by failure to pay the quit-rent.

Half-morgen hut sites were also granted at an annual quit-rent of 2/6 per plot.

After seven districts in the Transkei had been surveyed and allotted the practice was discontinued. The cost of survey was more than the land could bear, and efforts to devise a cheaper form of survey have been unsuccessful. The survey was carried out without expert agricultural knowledge and some of the plots are on ground which is inferior for arable purposes.

Plots are often demarcated with a fence of Mexican Sisal, aloe or other live fence, and sometimes with a post-and-wire fence. The general opinion appears to be that the grant of a secure title has not had any noticeable effect on the standard of cultivation. Anything in the nature of true mixed farming is impracticable, and the rule of forfeiture for non-cultivation prevents recuperation by leaving the plot down in pasture for a period of years, even if this were otherwise practicable.

When the quit-rent titles were introduced and the holdings surveyed, this applied only to the arable land. Pasture was left, as before, to be used in common, with the results which have invariably been associated with the system. The enclosure of self-contained holdings including a portion of pasture land is held to be impracticable for several reasons. The cost of fencing would be great, an important consideration when it is borne by Government. Neither the use of live fences nor the erection of fences by the title-holders themselves appears to be considered feasible. It is held that separate enclosures would be necessary for arable and pasture, as suitable arable land is found only in particular situations. Moreover, the pasture varies in type and quality. These variations can be utilised in communal grazing, but the holder of an enclosed portion might find its limitations serious. No individual claims have been staked out on the pasture and the idea of grazing "in severalty" is an entirely foreign conception to the inhabitants. Provision of access to water would be a difficult matter. It is obvious, too, that since stock ownership is so unevenly distributed, the settlement of individual rights, unless done by mutual agreement, would raise almost insuperable difficulties. To divide the pasture equally would be to force the owner of 2,000 head to dispose of most of them, probably at a financial sacrifice, and certainly at the sacrifice of his prestige, while many small owners would be unable fully to stock their holdings. To divide the pasture in proportion to stock ownership would be to take away from the small owner even that which he hath and to confer on the large owner in perpetuity a property which was his only to the extent that the state of his fortunes at the time enabled him to secure the use of it.

WOUNDS

"He jests at scars who never felt a wound" might be the rueful complaint of every plant that grows; for every one of them is always being wounded and bears innumerable scars from the battle of life. The root tip encounters an obstacle in its downward path. So tender is it that the slightest pressure interrupts the uniform distribution of growth-substance, a chemical manufactured by the root tip for the control of root growth. The tip forthwith curves away from the obstacle and, having circumvented it, straightens out once more and goes on growing downward. Any cut or bruise sets up a wound fever in the plant that suffers it. Its temperature rises; a sign that the plant is not going to take its punishment lying down. It does not. Like a dog licking its wounds, the plants bathes its wounds with a healing lotion, but where the self-heal medicine comes from is not quite certain. It used to be thought that it came only from the wounded and moribund cells—a dying bequest to those that come after them. It must come, in part at least, from the injured cells. Experiments show that. Wound two potato tubers; wash one wound and leave the other unwashed. The unwashed wound heals quicker. If doctors had known that they would have discovered far sooner than they did that asepsis is better than antiseptics. "Suck the place and make it well"—that is what we used to be told when we were children and had hurt our fingers. Certainly vulgar, but probably sound! In any case, it is something like that with plants. Your spade slices a turnip. If you felt compunction for your carelessness and wanted to comfort the turnip and make it well again, the best thing would be to rub its wounded surface with some turnip pulp. The pulp contains a hormone—a wound hormone—which calls upon the cells below the exposed surface to get to work. They do. They grow. they divide and form a wound callus—a barrier keeping out all bacterial and fungus callers who might pester the patient. Behind that screen cork forms—a solid though thin layer—and the damage is repaired. It was only the other day that the chemical nature of this wound-hormone was discovered. It bore an outlandish name; but the discoverer thoughtfully rechristened it and now it bears a name descriptive of its healing powers—traumatic acid. Perhaps, presently, we shall dispense with the old plasters such as wax or cow-dung for covering the large wounds of lopped branches. We shall anoint them now and then with this acid of healing and the wounds will heal faster. Yet the scars of them will never fade away; not even though the young wood grows and curls a little more each year over the cut surface until at last it covers the whole stump. A creditable bit of plastic surgery!

Reference: *The Gardeners' Chronicle*, Vol. CVII, No. 2778, p. 135, 1940.

SOME RECENT OBSERVATIONS ON THE FEEDING VALUES OF SOME LOCAL ANIMAL FOODSTUFFS

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanganyika Territory

(*Received for publication* 17*th August,* 1940)

Investigations into the compositions and feeding values of local animal foodstuffs have been carried out for the last nine years at Mpwapwa. The results of such work are of enormous importance in planning and developing future animal industry progress and, when war demands that all local resources should be utilized so that maximum production is attained, it is necessary that the gap between the research worker and the practical farmer should be bridged as quickly as possible. This article therefore reports the results of recent investigations and indicates how the foodstuffs can be best utilized by the farmer.

Edible Canna tops and tubers

The edible canna (or Queensland arrowroot) has been bred and improved considerably in recent years, it has gained fame as a source of starch and human food, and it has become established as a valuable stock feed.

Edible canna tops can be fed to milk cows, fattening oxen and pigs, and also to horses, donkeys, sheep and goats. If cut before the plant reaches maturity they are very palatable and greatly relished, but it often happens that the stock take a few days to get accustomed to their taste when they are introduced into the ration for the first time. Not only the green tops but the tubers are also of high feeding value, and can be fed to pigs, cattle, sheep and goats.

This plant is capable, when the soil and climate are favourable, of producing some extremely heavy yields of tops and a weight of tubers equal to any, and superior to many, other root and tuber crops. It grows quickly, and will give good yields in a short rainy season, but the best returns are obtainable when an adequate rainfall is combined with a fertile soil. Although the plant can stand drought very well, little growth is made in a normal dry season unless the area is irrigated.

The plant is propagated by means of the tubers or from shoots detached from a parent plant. The tubers are either cylindrical in shape tapering to a point or roughly oval, and very many can be obtained from one cluster. The stems are rather thick and succulent, whilst the leaves are of an elongated elliptical shape. The vegetative part of the plant may reach to over eight feet high, but under our dry conditions at Mpwapwa a height of over five feet is rarely exceeded and the crop yields are much below the best attainable.

There are many useful characters about the edible canna which suggests that it would fit well and easily into East African conditions. The tubers store very well or can be left in the ground until required; they may also be planted in dry soil some time before the rains are expected. The tubers are easily lifted, as they form large clusters, and can be fed sliced and raw, or after cooking. The leaves appear relatively free from parasitic attacks, and make very rapid growth after the rains.

The Mpwapwa samples compare well in their composition, digestibility and feeding values with samples from other parts of the world. The tops are very similar in nutritive value to Napier (elephant) grass when 3 to 4 feet high. The tubers have a very different composition, are highly carbonaceous, and contain but small amounts of protein and mineral matter. They compare closely in feeding value with cassava and sweet-potato tubers.

Velvet Beans

Velvet or Florida beans are a species of *Stizolobium* which have been considerably improved during the present century for stock-feeding purposes.

This legume grows long trailing vines, and can produce very heavy crops of fodder. It is usually grown with maize so that the vines grow up the maize stalks. When the maize cobs and some of the beans have been collected cattle are usually turned in to eat off the fodder mixture. It is often commonly grown by itself and turned into hay before the pods ripen, but owing to its very succulent pods and stems it is more difficult to cure into hay than most leguminous crops.

The ripe pods and seeds are now becoming of tremendous importance in the feeding of dairy cattle. They are ground into a meal called velvet bean feed, and are very palatable and of high feeding value for milking cows,

cattle and even horses (if not fed more than eighteen per cent of the concentrate ration). The dry beans may also be fed to stock but usually a greater bulk of food is obtained by grinding them with the pods.

In a previous work[1] I have shown that velvet bean hay made at Mpwapwa has a high feeding value equal to that of cowpea hay. The cowpea is usually regarded as the best of the leguminous crops and, as was shown recently,[2] can give higher yields of both hay and seeds. However, as shown in this latter article, the velvet bean is the more reliable leguminous crop for our hard conditions because cowpeas can be completely eaten off by insects.

In this country machinery is usually not available on up-country farms for grinding the pods and seeds, but the seeds can be threshed by native labour and ground in a maize grinder. Because of this, and because protein concentrates are so urgently needed in stock rations in Tanganyika, it was decided to determine the feeding value of the ground seeds. Normally, I think, this crop should be grown for hay or mixed with maize for ensiling, but there will be many occasions when it is impossible to make hay at the correct stage of maturity and when it will be more convenient to feed the seeds as a concentrate, and use the haulms as coarse fodder.

The crushed velvet bean seeds were found to have a very high feeding value and should therefore find a useful place in the dietary of live stock. They fully equal cowpeas, which are usually considered to be our best leguminous grains.

These beans are stated to be unsuitable for pig feeding, though I have always found them refused by swine. They can be fed to milking cows, cattle, sheep and goats with safety.

Wheat Bran

Wheat is becoming an increasingly popular crop in Tanganyika, and consequently larger amounts of wheat by-products are becoming available for the feeding of live stock. Usually the product sold as wheat bran corresponds to "straight run" rather than the "coarse" and "fine" brans of European countries. Wheat bran can form a most useful feed for all classes of live stock, and it was considered advisable to get all the information possible on the nutritive value of the article produced in Tanganyika.

Past work has shown that the local product had a very similar feeding value for pigs as that which would be expected from European experience, and so it was decided to find its value for ruminants.

The figures for the analysis of wheat bran in Tanganyika indicate that the local produce does not compare closely with the wheat offal fractions separated in Europe, and also show that the local product varies somewhat from one consignment to another.

The mineral composition corresponds with European analyses and calls for a few words on the use of bran. Bran is rich in phosphates and magnesia, but poor in lime, and is thus unbalanced in its mineral constituents. It is said that if fed in large quantities it may cause a loss of calcium from the body, and millers' horses are said to be particularly liable to a form of rickets known as "Miller's Disease." Being rich in phosphorus it can, however, form a very useful purpose in Tanganyika by correcting any tendency to a shortage of this constituent, but it should always be given in a ration containing foods known to be normal or rich in lime.

The digestibility coefficients and nutritive values agree with those from other parts of the world. Wheat bran as prepared locally can therefore be fed in the same way as in Europe. It is a valuable food for improving the palatability and lightening the concentrate part of rations for cows, oxen, sheep, pigs, goats, poultry and horses. It has slight laxative properties if fed as a mash, and for this purpose is very useful for sick animals, for animals just after parturition, and for keeping open the bowels of horses on rest days.

Kapok Seed Cake

In certain areas of Tanganyika kapok production is being developed and this article records an experiment to determine the feeding value of the residue from kapok seeds after the oil has been extracted.

The cake supplied was not in lumps of irregular size like the corresponding products from groundnut and sesame oil extracting mills, but was almost in the nature of a coarse meal. The product was less oily in appearance than the other cakes on the market, and the high percentage of small particles of black seed coat are probably responsible for its more open texture. The colour is grey with tendency

[1] Annual Report, Dept. Vet. Science, T.T., 1935, p. 88.

[2] *E.A. Agric. Journal*, 4 (1938-39).

to the black of the seed coats. This particular consignment was not relished by stock, and some animals refused it completely. Sheep and cows would not eat it, but some oxen who refused large quantities would consume regularly between one and two pounds daily.

The experiment was made on a batch of cake which was less musty than the main bulk. It was found that this cake differed from groundnut or sesame cakes by containing much more fibre and less protein, but had a similar mineral composition. For oxen, it was found to be only half as digestible as the other oil cakes and to be of much lower nutritive value.

Kapok seed cake is thus of relatively low feeding value, and not so good as green grass, wheat bran or the other cereal and oil mill by-products. If of good quality and not musty it could be fed to dry cows or oxen in the dry season when grazings are scarce.

The Leaves of Ficus Sycamorus

In discussing the feeding conditions of the cattle on the island of Ukara[1] I stated that the stock were hand fed indoors for a large part of the year, and that amongst the food brought to them were the young shoots and leaves of many trees. The majority of these trees belong to some eight species of wild fig and include *Ficus sycamorus*. This latter species is widely spread in Tanganyika, and it is no uncommon sight to see cattle in the dry season snatching leaves from the low hanging branches as they pass these trees. These trees in the Central Province usually carry a heavy crop of leaves in full greenness when all the grazings are completely dried up.

Because of their recognized feeding value in Ukara, and their attractiveness to stock in the semi-arid areas, it was thought that a number of farmers might be interested in their feeding value.

Analysis has shown that these leaves are moderately rich in protein and soluble ash constituents, and that the fibrous constituent is small. They are, however, not highly digestible. Their content of digestible protein is low, but their starch equivalent value compares well with that of many grasses at the flowering stage, and is superior to that of dried-up veldt grazings in the dry season.

Sheep and cattle have shown a liking for these leaves, but their feeding value does not warrant the expenditure of money in collecting them for stock.

Banana Plants

Data referring to the chemical composition of the banana plant and its different components are very few and scattered in the literature, and such information as is available usually refers to the manurial value of the vegetative parts. Indeed very little attention has been paid to the feeding values of the different portions of the plant when fed to live stock. This latter question is of considerable importance in Tanganyika, and information on this point will not only be of value locally but also to the large banana-growing areas of the world.

My attention was first drawn to this problem during a blood survey of the Chagga cattle living on Mount Kilimanjaro.[2] The Chagga tribe have settled a belt along the lower slopes of the mountain, where the fertile volcanic soil and plentiful supplies of water (for irrigation) combine to support a dense population practising a very intensive type of mixed farming. Each Chagga smallholder has planted his beloved bananas round his house, and these groves stretch for miles and form a characteristic feature of the countryside. In this area of intensive cultivation practically no grazing land remains, and the cattle are of necessity stall-fed. They spend practically their whole lives penned inside the family hut, and are fed on weeds from the cultivated areas and on grasses, cut and carried to the huts daily by the women, from the plains at the foot of the mountain. No water is brought to the stock; the women bring in fresh green grass for two days, and the third day the smallholder cuts down a banana tree. The stem and leaves of the banana are cut into thin slices and fed to the animals. The high water content of the banana plant, together with that of the green grass, is considered sufficient to meet the demands of the stock. In fact, the Chagga say that if the stock are allowed drinking water in addition to the banana plants diarrhoea and other digestive disturbances follow. Besides the trunk and leaves, all banana skins and fruit stalks are fed to the stock, whilst in good seasons even whole bananas may be fed.

[1] Annual Report, Dept. Vet Science, T.T., 1933, p. 62.

[2] Annual Report, Dept. Vet. Science, T.T., 1935, p. 81.

A similar, though much less intensive, system of husbandry is spreading on the lower slopes of Mount Meru. In Bukoba the large banana plantations are not used for cattle feeding but are allowed to rot and form a mulch for coffee. Bananas are grown widely along the lacustrine and coastal belts of Tanganyika Territory and are also to be found along many of the watercourses and wetter areas of the semi-arid central plateau. They hold an important place in the dietary of the tribes living in the heavy rainfall highland areas in the south of the Territory. So far as I know, it is only in the Meru–Kilimanjaro area of this Territory that the banana plant, after fruiting, is cut down and fed to live stock, but it seems desirable that this practice should be more universally adopted.

Chopped banana plants contain a very high proportion of moisture (90 to 95 per cent), and the dry matter is low in protein but rich in carbohydrate and soluble mineral matter. The fibre content is less than in local hays or grasses at the flowering stage. The soluble mineral matter contains large quantities of potash, and is rich in lime, soda and chlorine, but the phosphate content is not correspondingly high.

Banana chop proved highly digestible, and the dry matter has a productive value greater than that of mature grass, grass silage, hay or maize silage; but though possessing a good energy-producing value, the plant is very poor in digestible protein, and consequently should be fed in a ration which will correct this deficiency. As a succulent food for the dry-season feeding of cattle, the banana plant has considerable possibilities. The large proportion of water which dilutes the feeding value of the freshly cut plant is a disadvantage in that large quantities have to be fed; but this succulence has a very beneficial effect on cattle, and reduces their water requirements.

The high feeding value of its dry matter combined with the succulence of the plant indicate that discarded banana plants are worthy of a much wider utilization as a stock food. Wherever it is advisable to encourage or to maintain existing banana cultivations, every effort should be made to persuade the natives to feed the trees, after the fruit has been gathered, to their live stock. Even on the European farms the feeding of banana chop would reduce the silage requirements.

If banana plants were allowed to wilt until their water contents were reduced by half, there would be little difference in feeding value between wilted banana plants and fresh Napier grass.

Cattle will eat up to 30 lb. of chop daily, but they have to be accustomed to it gradually. Once the animals are used to it, they will eat the banana chop very greedily.

Other observations recorded in these tests were:—

(1) The feeding of chopped banana plants to cattle considerably reduces the amount of water drunk.

(2) Cattle can consume up to 30 lb. daily of banana chop.

(3) Banana plants exert a very beneficial influence on cattle living on dried hay; they produce a good coat, improve the general appearance and lead to greater rates of liveweight increase.

(4) The milk from banana-fed cows is not tainted.

The digestible nutrients and feeding values of the dry matters in the foodstuffs mentioned in this article are given in the accompanying table.

THE DIGESTIBLE NUTRIENTS AND STARCH EQUIVALENT VALUES OF LOCAL FOODSTUFFS FOR RUMINANTS

(Per 100 Parts of Dry Matter)

Foodstuff	Velvet Beans	Wheat Bran	Edible Canna Tops	Edible Canna Tubers	Kapok Seed Cake	*Ficus sycamorus* Leaves	Banana Plants
Digestible Crude Protein ..	20·08	10·52	4·47	1·60	10·63	2·45	3·47
,, Ether Extract ..	2·81	1·62	1·39	0·49	2·91	1·25	0·45
,, N-free Extract ..	57·03	46·00	31·96	76·06	27·05	31·00	47·56
,, Crude Fibre ..	6·57	1·79	6·86	3·01	2·33	4·64	12·70
,, Organic Matter ..	86·49	59·93	44·68	81·16	42·92	39·34	64·18
Starch Equivalent	85·78	48·28	34·28	81·51	39·96	32·04	57·51
Nutritive Ratio..	1:3	1:4	1:7	1:5	1:3	1:15	1:18
Usual Moisture Content ..	11	12	83	70	12	70	90–95%

THE ERADICATION OF THORN TREES*

By J. D. Scott

In various parts of South Africa where the intrusion of thorn threes is encountered the problem of their eradication arises. In some parts these trees grow so densely that grazing has become impossible. Not only do they take possession of large tracts of country but they also impede the growth of vegetation of every kind. For this reason the ground becomes denuded and, consequently, is exposed to erosion which becomes severer as the trees increase in number.

To-day many farmers are fully alive to the danger of the situation. Judicious veldt-management alone can restore to the veldt its original value. In the first instance it is necessary that the thorn-veldt should be eliminated. This means that where deterioration of the veldt has already been observed the problems connected with the eradication of bush must be tackled before any measure of success in regard to veldt-management can be expected. Experiments have shown that where dense patches of trees, which had already reached maturity, were eradicated, the veldt improved within an incredibly short space of time. It is a well-known fact that the thorn-veldt is more liable to decline under incorrect practices than any other type of veldt, but there is also the compensatory fact of the great likelihood of its recovery under correct treatment after the trees have been eradicated. This important work of reclamation demands one thing, however, and that is that the expenses connected with the eradication of the trees should be kept low.

There are persons who have found to their cost that the eradication of trees by manual or mechanical labour is both uneconomical and impracticable. Work carried out by Dyer in the Cape Province has proved that thorn trees can be eradicated successfully by cutting them down and then pouring arsenic pentoxide over the stumps. Farmers object to the use of arsenic pentoxide, however, on the ground that their grazing paddocks become contaminated with an indestructible poison. Neither is the use of sodium chlorate very desirable, because it becomes explosive immediately it dries.

Preliminary experiments which were carried out during the summer of 1938-39 have proved that ordinary power paraffin, applied to the bark of a thorn tree, immediately penetrates to the tissues of the tree and results in the death of that portion of the tree above the point of application which is generally level with the ground.

From an investigation of trees treated during the previous season it appeared that a large number sent up new shoots from nodes just below the ground. Certain trees which were treated below the surface level were quite dead.

Upon the basis of these results, 700 trees were treated during the summer of 1939-40 with ordinary as well as power paraffin, both above and below the level of the ground. The method adopted entailed the clearing away of the soil around the tree to a depth of two to three inches in order to expose the stem at the junction of the bark above and below ground. The nodes from which new shoots grow are encountered at this point. As soon as this bark is exposed it is treated with paraffin, which is applied as a fine spray or with a brush to a width of two to three inches all round the trunk.

The results obtained during this season show that there is little to choose between ordinary and power paraffin either when used alone or mixed with other poisons.

The trees may die within a week or they may show no external signs of poisoning for a few months and then suddenly die. The results to date indicate that by this season 60 per cent of the trees were already dead, 30 per cent were dying and fewer than 10 per cent were beginning to grow again where the treatment had been applied below ground level. Where the trees were treated above ground level only 34 per cent are dead, 32 per cent are dying, and 34 per cent are beginning to grow again. Up to the present, this method of treating thorn trees with power paraffin has proved the cheapest yet discovered. When used with a spray-pump, one gallon of paraffin is sufficient to treat 100 trees, but if a brush is used, this method naturally being slower, about 200 trees can be treated with one gallon. The cost of digging the soil away from the stem of the tree and of the paraffin used amounts to approximately 2/- per 100 trees. This sum also includes the cost of hiring a European overseer.

This method would therefore appear to be cheap, effective and safe, and may prove of great value in the eradication of thorn trees.

* Reprinted from the *Weekly Press Service* of the Department of Agriculture, South Africa, 11th June, 1940.

REVIEWS

SOIL CONSERVATION, by Hugh Hammond Bennett; 960 pp.; Sh. 40/-; London, McGraw-Hill Publishing Company, 1939.

The Head of the Soil Conservation Service of the United States Department of Agriculture, the master and highest authority on soil and water conservation to many disciples spread all over the world, has presented us with the results of thirty-six years of his unremitting fight against the cancer that threatens modern civilization as it has threatened—and overcome—more than one of the older civilizations.

With its 960 pages of text, its 360 well-chosen and clearly reproduced illustrations, and its comprehensive index of 36 pages, the book is an encyclopaedic representation of our accumulated knowledge of the erosion process and all its consequences, as well as of the methods for countering them; although Dr. Bennett seems to regret that limitation of space has not permitted him to use all the material available for a complete treatise on the subject!

The driving spirit, traceable throughout the book, is a conviction that the evil can be stemmed by "working with, rather than against, natural forces, and by provident action based on a thorough diagnosis of the present problems of land use"; and that this "can only be achieved by co-ordinating the knowledge of many sciences toward a common object." It is evident that such a treatment must raise the problem high above the status of a mere accidental stage in the history of *homo sapiens* and weld it securely into the universal pattern of geography: No wonder, therefore, that the work has appeared as the latest of the fine volumes in the "McGraw-Hill Series in Geography," which are such a joy to handle and to study.

It is, of course, out of the question to attempt to do justice in a short review to the vast amount of carefully digested raw material, and all one can do is to give a concise account of the general arrangement and thereby to draw attention to the fullness and many-sidedness of the book that make it a reference work *par excellence*. The price of Sh. 40, especially when compared with that charged for many other modern scientific productions, is ridiculously low for what is offered; and yet one cannot but regret that it will no doubt prevent many who ought to benefit from this masterpiece from buying their own copy. All the more reason that every office of the colonial technical departments concerned, not only at headquarters, but chiefly in the districts, should possess at least one copy for easy and constant reference by all its officers.

Although the great bulk of the work deals, quite naturally, with conditions, practices and organizations prevailing and evolved in the United States of America, this need not detract from the world-wide usefulness of the book. For where could we find a better school for preparing our own fight, where a nobler example of putting the whole resources of a nation at the command of those who are earnestly tackling the terrific task of saving the people's inheritance by making them soil- and water-minded in the modern sense? Besides, in many parts of East Africa natural conditions have much in common with those met with in the worst eroded parts of the United States, and a good many of the illustrations might have come straight from Tanganyika Territory or Kenya instead of from Colorado, Texas, or Oklahoma.

The work falls naturally into two major parts: (1) The Problem, and (2) Conservational Counter-measures. Part I starts with a historical review of the problem in the United States and with a most fascinating glimpse into the past interaction between erosion and civilization; from which it becomes clear beyond doubt, as I had always maintained, that "the history of soil erosion is an integral part of the history of agriculture," and begins wherever the demand for land exceeds the primitive supply and thereby destroys the conditions of primitive farming which were (and still are in certain regions, e.g. among the forest and savanna Bantu of Central Africa) closely adapted to the environment. Then follows a long chapter on the results of present-day erosion, well documented by figures and well illustrated by photographs which show what human greed and shortsightedness can make in a short time of our earth's lovely face and remind one of the horrors of a pathological museum exhibiting the results of man's vices on the organs of his body!

Principles, processes and types are next dealt with, again in a magnificently illustrated and clearly written account. The next chapter, particularly interesting to the hydrologist,

treats of erosion and run-off, and emphasizes our deplorable lack of knowledge, positive and detailed, regarding a number of less evident contributory factors than slope, soil type and cover. One misses a reference to recent experiments on run-off from grazed woodland and, in the biological section, to termites. The chapters on the relations of soil erosion to soil properties, climate and infiltration are packed with valuable information, especially the last affording considerable help to the student of a subject where a great deal is still decidedly "dark". Next, the relations to crop yield and vegetative changes are thoroughly explained and illustrated by many examples. Then follow three illuminating chapters on sedimentation, that counterpart of erosion which likewise destroys so much good land; on mass movements which form under certain conditions an important factor in soil removal and have until recently been more or less overlooked by the student of soil erosion; and on the effects of lithological and geological structure. A few pages on the relations of insect life to erosion conclude this first part, which occupies approximately one-third of the whole book.

Part II covers the wide field of soil and water conservation and land-use betterment. It starts with setting out the United States national programme, which attempts to make far-reaching adjustments in a complex land economy to prevent "national decadence by capitalizing on experience and advancing through research." The technical details are discussed in fourteen chapters which make up another third of the volume and provide ample and well-arranged material for those concerned with the practice of anti-erosion and flood-preventing works. The now apparently inevitable discourse on wild-life in connexion with conservation, which is such an excellent lure for the happy-go-lucky masses of mankind, is of course included.

The last third of the book is taken up by a number of chapters in each of which a specific and typical part of the United States is treated regionally, a treatment well designed to bring out the geographical aspects of the use and misuse of land and of the varying methods of control and readjustment. Neither is the historical aspect neglected. Each of these regional studies makes interesting and instructive reading, especially those on the Great Plains and on the Colorado River Basin, the latter with many East African affinities. A note on early efforts toward erosion control in the United States concludes this regional survey; and three concise chapters on erosion problems in foreign countries, on research, and on conservation surveys, take us to the end of this admirably told long story of human folly and awakening.

C.G.

A Report of a Journey to Parts of the West Indies and the United States for the Study of Soils (February to August, 1938), by G. Milne; 78 pp. Sh. 2/50; Dar es Salaam, Government Press, 1940.

To send scientific and technical officers from the Colonies on study leave and to benefit from the bounty of the Carnegie Corporation has become very fashionable of late. Only rarely, however, is a wider interested public permitted to share the results of such studies. The East African Agricultural Research Station must therefore be thanked for the publication, even in time of war, of this lengthy but most valuable report by its Soil Chemist. In it Mr. Milne has once more given us a splendid example of his clear mind, which pierces the complexity of nature's interacting processes, bases them on a philosophical foundation, and expresses the results in language refreshingly free from scientific jargon. He can also be delightfully sarcastic if it suits him to bring out a point, as, for example, when he describes Marbut using Schantz for his periscope, or talks of the "pedological papacy in Washington".

The main purposes of the journey were to see representative soils in the West Indies and California, and to visit other parts of the United States where research and field work in soil conservation are in progress. Throughout his wanderings over soils of the greatest imaginable variety the author took every opportunity for applying what he saw and learnt from his American colleagues to East African conditions. After a short but instructive chapter on soil maps, in which the usefulness of air pictures is stressed, the relation of soils to rock and physical geology is discussed. Several pages are taken up by a very interesting account of "very young soils," especially of their unpleasant habit "not to keep still," and of their reactions to normal and accelerated erosion. As examples of truncated soils that have developed on their own lower horizons certain lateritic soils in British Guiana were visited

and as the results are not only of great interest in the field of soil genetics, but are of outstanding importance to East Africa, a special section of the report is devoted to them. The reference to "soil creep" (p. 20) and its effect on what are now usually called "stone lines" in exposed soil profiles is interesting; I have myself tried to explain this phenomenon by gravitational movement as long ago as 1931. Talking of pediment soils in the eastern United States and of their great similarity to our own pediment and plateau soils, the general truth is established that "truncation of a soil by erosion throws it back to a closer dependence upon the properties of its parent material".

Turning to climate, that bugbear of the pedologist, one is reassured from the very beginning—as was to be expected from Milne—that the zonal soil "ideal" is far from realized where geology, topography and length of surface exposure form a varied, dovetailing pattern as they do in many parts of the world, certainly in East Africa; and that, as a consequence, in such regions "climate is displaced from its position as a simple major control." Then follows a most lucid description of man's attempt to overcome climate by irrigation, as seen in California, where its success is due to the very fact that soil patterns exist which do not represent the "normal" soil expectation for this particular type of climate but are "collateral results of the ruling regional conditions," i.e. of a juxtaposition of mountains and plains. In this connexion grave warnings are issued, and fully endorse those repeatedly uttered by the reviewer, that no, not even minor, irrigation schemes should be undertaken in East Africa without prior detailed surveys of soils and land classification. There is also an important reference to increased utilization of our "mbuga" soils for the growing of cereal hay crops ("grain hay" as they call it in California, where it is raised on identical heavy cracking clays); as also by the Guiana method of "flood fallowing," which serves to ameliorate these heavy soils and to which a special chapter is devoted in Part III as, the author thinks, it may be applicable under certain environmental conditions in East Africa. An experiment in this direction seems well worth while, perhaps best in the low-lying "mbugas" around the southern end of Smith Sound. The chapter ends with one of Milne's gems of soil philosophy: He sees that our world-wide trouble with soil loss by wind and water erosion is due primarily to the fact that "Man has overreached himself in his kickings against the climatic pricks", a state of affairs that can only be overcome by deepening our knowledge of the interactions of climate, vegetation and soil.

Such considerations automatically lead to the ever-fascinating subject of soils and vegetation. As readers of this Journal have been given the substance of the author's views in the January 1940 number (pp. 294-298), I need here only emphasize one or two points of outstanding importance. Firstly, there is an excellent exposition of the dangers inherent in drawing from the natural vegetation conclusions as to what crop can successfully be grown on the same site, and he illustrates this by valuable examples of mistaken attempts to used cleared forest soils. Then there is a warning against the dangers of giving over forest land, destined for the replacement of natural by commercial forest, to the cultivator for even a short time, instead of preserving the continuity of true forest conditions of the soil through the transition period; a mistake being, I believe, at present repeated in the Shume area of Tanganyika Territory. And finally there is the emphasis on the constructive use of vegetation for maintaining soil structure and fertility; in other words, "If the soil is to continue to grow plants for us, in turn we must grow plants for the soil."

Lack of space forbids to analyse more closely the chapter on morphology and classification packed with useful information. I can only draw attention to the fruitful suggestion (p. 36) to add to the accepted horizons of the soil profile an "M-horizon," coinciding with the horizon of cultivation, the depth and character of which is being determined by man; and to the "duricrust" horizons which are of such importance in East Africa and elsewhere, not only to the agriculturist but to geologists and morphologists in their endeavour to decipher the history of the earth's surface. To such as me, averse to forcing nature's dynamic flux into the procrustean bed of static classification, it is pleasing to note (pp. 41-42) the views of Professor Jenny of the University of California, who dismisses all classification as fruitless.

The lengthy chapter on soil surveys and their intricacies will interest the specialist rather than the layman, although the latter is strongly urged to read attentively the résumé given in the May 1940 number of this Journal (pp. 436-442). To my mind the most important of many matters discussed are the realization that a mere mapping of soil profiles is not

enough, and that the older notion of a soil type should be replaced, or supplemented, by that of a natural land type. Above all, the philosophy of the new methods of soil surveys has to be evolved *pari passu* with the actual field work if the latter is not to outrun understanding.

In the last chapter on conservation, of which the July number of this Journal gives the substance (pp. 26-31), one is glad to see that in America the geomorphologist is apparently allowed to play an integral part in the necessary investigations, and that the hydrographer and plant physiologist are indispensable for determining the function of that part of the hydrographic cycle which, through the soil, feeds the plants.

A number of special subjects are dealt with in a supplementary Part III.

C.G.

LOOK AROUND YOU SERIES NO. 1, COMMON VELD FLOWERS, by J. C. F. Hopkins, Senior Plant Pathologist, Department of Agriculture; Aline L. Bacon, Professional Assistant in Botany and Plant Pathology, and L. M. Gyde, Science Mistress, Girls' High School, Salisbury, Southern Rhodesia; 124 pp.; Sh. 3/-. The Rhodesia Scientific Association, Salisbury.

"For many years teachers of botany in Rhodesian schools have complained of the absence of some elementary book on the local flora upon which they could base a suitable course for their pupils. As a result of the continued support of the Government and specific grants for publications made by the Beit Trustees, combined with judicious spending on the part of the R.S.A. Council, sufficient capital has been accumulated to cover the cost of printing this little handbook, and if the venture proves successful it is hoped that other authors may be persuaded to continue the 'Look Around You Series' with such subjects as 'Butterflies and Moths,' 'Snakes and Lizards.'"

In a period when half the civilized world is engaged with the forces of destruction it is refreshing to know that there are still some who can envisage construction for the younger generation. The authors of this little handbook and those who made its publication possible in these difficult days are to be congratulated on its production and format. The book is well illustrated with figures and photographs, and over eighty-six genera have been dealt with by the authors.

A section is devoted to plant forms, covering plant morphology, the classification of plants, collecting and preserving of specimens, all of which are illustrated by well-drawn figures. A page and a half is devoted to an alphabetical list of families and genera referred to in the book, then to a section, "Striking Characteristics of Some Families of Flowers." The main text then begins with "The Grasses and Sedges," followed by "Cape Pond Weed" and ending with the Wild Lettuce and a glossary.

As an indication of the type of information that is supplied in the main text I give the main headings of an East African example that is well known to everybody:—

> Water Lily (*Nymphaea capensis* Thunb.—Nymphaeaceae); Time of Flowering; Habitat; Habit; Rootstock; Stems; Leaves; Flowers; Fruits.

Under each of these a brief description is given and at the end general information is supplied, such as ornamental purposes, horticultural possibilities, including such items as "Pools in which water lilies grow should be avoided as the plants harbour the snails which are the alternate hosts of the Bilharzia parasite." Quite often notes on native economic uses are also given.

Most of the generic or specific descriptions are accompanied by one or more photographs of the plant, e.g. of the water lily there are two, one showing habit and the other habitat. The majority of these are good, and help a beginner to recognize the plant or genus under discussion.

The authors do not state what system of classification they have followed should one wish to go further with the subject, and the majority of the descriptions are confined to annual or perennial herbs. The selection has been made in order to include when possible "at least one member of each family laid down in the Cambridge School Certificate syllabus".

The book should be invaluable to teachers of botany in schools in Southern Rhodesia, Nyasaland and Northern Rhodesia, as the species dealt with are common to those regions, and it will be nearly as useful in East Africa where a number of the species and most of the genera are represented. It should also be on the bookshelves of anyone with a general interest in the flora of East Africa, for its illustrations and descriptions are of assist-

ance in recognizing the more common genera that one frequently sees in the field without knowing their scientific names.

I note that the authors have not always followed accepted botanical nomenclature. For example, p. 78, Red Wings, *Combretum Oatesii* Rolfe, is now considered to be the same as *C. platypetalum* Welw. ex Laws.; p. 100, Witchweed, *Striga lutea* Lour., a widespread parasitic weed on maize, etc., in East Africa, should be *S. asiatica* (L.) O. Ktze. The use of capital letters for some of the specific names has not been consistent and proof-reading could have been done with more care as there are a number of spelling mistakes and printer's errors. These, however, are details which can be rectified should another edition of this very useful little handbook be called for.

P.J.G.

THE INDIGENOUS TREES OF UGANDA, by W. J. Eggeling, B.Sc., Ph.D., Senior Assistant Conservator of Forests, Uganda Protectorate, with a Foreword by Sir Arthur Hill, K.C.M.G., F.R.S., Director, Royal Botanic Gardens, Kew; xxii+296 pp., with 42 photographs and 76 line drawings; Sh. 15/-; Government Printer, Entebbe, Uganda.

Dr. Eggeling and the Forest Department, Uganda, of which he is a member, are to be congratulated on the production of this useful and well-illustrated book of the indigenous trees of Uganda. It is a most helpful step as a preliminary to a much-needed Flora of Tropical East Africa, for the preparation and publication of which Kew has been endeavouring for some years to obtain funds from the East African Governments.

The first twenty-two pages are occupied with introductory matter together with a Key to the Families which has been adapted mainly from Hutchinson's *The Families of Flowering Plants* and from Hutchinson and Dalziel's *Flora of West Tropical Africa.* Indeed, no one in Uganda need now have difficulty in identifying his trees, as there are keys to the genera and species as well as to the families, a very valuable feature. The bulk of the book contains descriptions, photographs, and drawings of the different species of trees found in Uganda. In his arrangement, Dr. Eggeling has not followed a phylogenetic system of classification, but has arranged the families, genera and species alphabetically, which should suit those with no botanical training, as a rapid means of reference.

To quote an example: In the genus *Dracaena* there are two species only. A key based on leaf characters showing the differences between the two, *D. afromontana* and *D. Steudneri,* is provided. Under each a full description of the plant is given, together with citations of specimens seen and examined, most useful when there are duplicates of the same collections in other herbaria. Synonyms, common names, native names and uses, habitat and geographical distribution in Uganda are given.

Where the tree is of economic importance for its timber, trade names are quoted and information on working qualities and uses has been included. The vernacular names have been fully authenticated by as many as three different observers, but, as the author points out, the native is not consistent in applying his names to the trees of his native land and they cannot be relied upon for identifying a given species.

Other valuable features are very well reproduced photographs showing the habit of a number of species; and, as an aid to the identification of others, should one have difficulties with the keys, the simple but effective outline drawings are all that could be desired. The book concludes with corrections and additions, some blank pages for notes, abbreviations of authors' names, glossaries of botanical terms, vernacular, common and trade names, and an index to genera and species.

I note that a number of specific names have been reduced to synonyms. The changes affect, at least potentially, all systematic work on the African flora, and it is greatly to be desired that the authority or reasons for such changes should have been given. The author has also used a number of manuscript names which cannot be accepted as effectively published according to the International Rules of Botanical Nomenclature as they are not accompanied with Latin descriptions. These will entail further name changes unless the botanist who describes and publishes them as new species according to the Rules retains their original specific epithets. The combination *Fagaropsis angolensis* (Engl.) Dale (p. 208) has never been effectively published by Dale, and should therefore not have been used. Also, the correct name for *Harpullia Fosteri* Sprague (p. 216) is *Majidea Fosteri* (Sprague) Radlk. according to "Das Pflanzenreich," Sapindaceae 4, 165; 1463 (1934).

The Government of Uganda appears to have not only a commercial interest in its forests but a scientific one as well, and it is to be congratulated on financing the publication of this book during the present time. The format and excellent printing reflect great credit on the Government Printer; a technical book of this nature with its photographs and line drawings is not easy to produce.

The book should not only be on the shelves of the people of Uganda but should be in the possession of all who are interested in East African trees, as most of the species are not restricted to Uganda.

P.J.G.

FIELD TRIALS: THEIR LAY-OUT AND STATISTICAL ANALYSIS, by John Wishart; 36 pp.; Sh. 2/6. Imperial Bureau of Plant Breeding and Genetics, 1940.

The importance of field trials in agricultural science is too well-known to need emphasis. Statistical research has enabled great advances to be made in technique, increasing considerably the value of experimental results for a given outlay in time and labour. The mathematical aspects of statistical research are often beyond the comprehension of the field worker, but it is essential that he should have at least a little knowledge of the principles underlying the technique he is adopting in testing agricultural theories, particularly when he is unable to appeal directly to the authorities in this branch of science. It is a great help to have a simple exposition of the methods devised by experts and particularly the application of these methods to specific problems, accompanied by illustrations of the arithmetical treatment of results.

This has now been provided by Dr. J. Wishart in a very useful bulletin describing the most recent developments in agricultural experimentation. He begins by discussing the principles to be adopted in laying down field trials and illustrates by gradual and easy stages the evolution of the experimental designs required to assess the more complex actions and interactions of increasing numbers of factors of agricultural importance. The author's explanations and examples lead the reader gradually to a better understanding of the problems involved. With this bulletin as a grounding he will be in a position to understand the methods developed more fully in other publications to which he must refer at a more advanced stage of his studies.

L.R.D.

THE CONTROL OF WEEDS: Editor, R. O. Whyte, Herbage Publication Series Bull. 27, Imperial Bureau of Pastures and Forage Crops, Aberystwyth, 1940; 168 pp.; Sh. 7/6.

The immense importance this subject may assume is illustrated by the example of one area in the U.S.A., where aggressive species, chiefly perennial, for which no adequate control has yet been devised, have become a real and growing menace; six million acres of excellent farm land west of the Mississippi are so thoroughly occupied by noxious weeds that continued crop production is threatened. In these circumstances it has been found necessary in eight States to establish research stations concerned with nothing but weeds.

The present publication provides contributions on weed control from a number of specialists, most of them resident in the U.S.A., Canada and Australia. An important article from South Africa, which is likely to be of special interest to East Africa, will probably appear later. The methods discussed include chemical control with sprays and soil treatment, control by methods of cultivation and crop rotation, and biological control by insects and by the use of smothering plants. It is curious to note that, in places such as the coastal districts of New South Wales, where the climate is suitable, bracken may be killed out by Kikuyu grass. Usually, however, useful plants have to be stimulated by high soil fertility to combat weeds.

An interesting item in the Bulletin is Pavlychenko's demonstration of root competition between crop and weed, a problem of special importance in areas of low rainfall.

SPECIAL NOTE RE PREVIOUS ISSUES OF THE JOURNAL

A limited quantity of the following numbers of the Journal is available:—

Vol. I, No. 4 only.
Vol. II, Nos. 1, 2 and 3 only.
Vol. IV, Nos. 2, 3, 4 and 5 only.
Vol. V, Nos. 3, 4 and 6 only.
Vol. VI, No. 1 only.

To be obtained from the Government Printer, Nairobi, at Sh. 1/25 each copy, post free. Remittance must accompany the order.

THE AMERICAN COTTON-GROWING INDUSTRY: SOME IMPRESSIONS–II*

By H. R. Hosking, B.Sc., A.R.C.S., A.I.C.T.A., Botanist, Department of Agriculture, Uganda

(*Received for publication* 15*th March,* 1940)

Texas

In 1936 the State of Texas produced 2,961,000 bales, which was nearly 28 per cent of the total crop of the United States. All this cotton is rain grown. In the extreme west the total annual precipitation is 15 inches, increasing to 45 inches in the east. Generally speaking, the greater part of the cotton is grown to the east of the 30-inch line. The northern half of the State experiences up to 10 inches of snow each winter; in the southern half, snow in the winter is less than one inch. (These figures refer to unmelted snow.) In 1938 the estimated yield per acre for Texas was 170 lb. of lint, giving an estimated total crop of nearly three and a half million bales.

A number of different varieties are grown in this State. The choice of variety has been left to the grower in the past, but to-day the Department of Agriculture is trying to organize one-variety communities among the farmers. Up to 1937 a large number of farmers grew the variety "Half and Half," so called because of its extremely high ginning percentage—stated to be as high as 44 per cent on saw gins. In 1937, however, this very short-staple cotton was difficult to sell, and many farmers have ceased to grow it. The Department of Agriculture has for some time discouraged this variety. It is used by the cotton breeders in crossing work to "boost" the ginning percentage of the standard Upland cottons.

The average staple grown in the State is around one inch; the average yield for the whole State is considerably less than half a bale per acre. If the disease known as Texas root rot, due to the fungus *Phymatotrichum omnivorum,* could be completely controlled, there is little doubt that the average yield would increase enormously. A large number of fields of cotton were seen in September with up to 50 per cent of the plants completely killed by this disease. It was very noticeable that where cotton had succeeded oats in the rotated strips there was relatively little of the disease.

The standard of cultivation of the cotton is extremely high in this State. Contour planting is invariably followed, and in many cases this is combined with listing, or planting on small contour ridges. The crop is grown chiefly in the area where the precipitation for the months of April to September inclusive varies between 18 and 24 inches. Strip cropping is widely practised, and where the slopes are above the average in severity the strips are reinforced with broad-base terraces. If the terraces are graded, carefully protected grassed outlets are prepared before the terraces are constructed.

During the first week of September a considerable acreage of ripe cotton was seen to have been ploughed under. The reason given was that certain farmers, on checking up their acreage, had found that they had an excess over the allocation under the A.A.A. restriction and could not afford to pay the penalty, so were forced to destroy some of their cotton in this manner.

The cost of ginning and baling is high in Texas; it has averaged just over $6.00 per 500 lb. bale for the period 1929 to 1936 inclusive. This fact, combined with the low average yield, makes the writer wonder how it is possible for the farmers to produce any cotton without suffering a loss. If it were not for the A.A.A. subsidy on each pound of lint produced, it would be impossible to grow any cotton at all in this State; and when one takes into consideration the large proportion of the country's crop which is grown in Texas one realizes how economically unsound is the cotton-growing industry.

The Mississippi Delta

The alluvial soils in the valley of the Mississippi River are found in the States of Arkansas and Louisiana on the west bank of the river and in Mississippi State on the east bank. As one would imagine, erosion on these flat areas is not a serious problem. In this way the alluvia of the San Joaquim Valley are comparable. The chief problem is to keep up fertility. The pressure on the land is very severe in the delta because of the high productivity of the soils and the climate, which is as near ideal for cotton as anywhere in the world. At the Stoneville Cotton Field Station it was stated that, although the soils were rich in potash and most of the other essential elements, the nitrogen

* Continued from July, 1940, issue (Vol. VI—No. 1).

content was very liable to decrease under intensive cultivation. This phenomenon is well known, and is closely connected with temperature. In the sub-humid regions nitrogen content is related inversely to rise in temperature; thus the delta area, with its high mean annual temperature (in excess of 60 degrees F.), is always liable to suffer from nitrogen deficiency unless proper precautions are taken. To keep up fertility it is essential to rest the land under lucerne for three years after three years of cotton. The Station also advocates a winter green manure crop, to be ploughed under before the cotton is planted in the spring. It is found that if excessive applications of nitrogen are made in artificials the cotton grows too woody and yield is reduced.

The rainfall of the delta area varies between 50 and 60 inches per annum, of which about 24 to 30 inches falls in the six warm months of April to September inclusive.

As in all the areas infested with boll weevil, the aim is to produce early maturing cotton, as it is found that bolls set after September will be destroyed by the weevil. Thus there is only a period of about 150 days in which the crop can develop and produce bolls which will be relatively free from boll weevil. Despite this serious limitation, the yields in the delta are high on the better managed farms. The estimated yields for the three States in question varied from 225 to 245 lb. of lint per acre in 1938. On the best farms yields of a bale an acre are obtained in good seasons.

The respective average ginning and baling charges for the States of Arkansas, Mississippi and Louisiana were $5.10, $5.20 and $4.59 per bale for the period 1929 to 1936 inclusive.

Labour is much cheaper than in California. The average picker, for example, is paid $0.50 per 100 lb. of seed cotton as opposed to $1.00 in California. A large proportion of the cotton is grown by share-croppers, small farmers who furnish the labour and receive in return a proportion of the crop produced. This system leads to serious soil exploitation, as does the monoculture practised in the greater part of the cotton belt. It is difficult to give an average figure for the cost of producing an acre of Upland in the delta, but it probably lies between $30 and $40 per acre. With a yield of 250 lb. of lint and 465 lb. of seed per acre, the gross return would be $25 for the lint at 10 cents per lb. and $3.72 for the seed at $16 per short ton; thus the total gross return is only $28.72 per acre. The A.A.A. subsidy of 2 cents per lb. lint adds $5 to this, making a total return of $33.72 per acre. So it can be seen that even when in receipt of the subsidy the farmer must average over half a bale per acre and keep his costs to the bare minimum to come out all square on the crop. Yet the three States mentioned above were estimated to produce about three and a third million bales between them in 1938.

Apart from the boll weevil, the other major pests of the cotton crop in the delta are Fusarium wilt, aphids, and army worms. By selection they are obtaining strains which are resistant to certain pathogenic strains of *Fusarium*. The Cotton Breeder of the Delta and Pine Land Company of Scott, Mississippi, is of the opinion that glabrous cottons are more resistant to aphid than hirsute ones. It is very noticeable that, after dusting with calcium arsenate to control the boll weevil, aphids increase enormously and cause defoliation. This is presumably due to the dust killing the natural enemies of the aphids. If the boll weevil attack is early, then this defoliation results in a reduced yield; if the attack is late, then defoliation is probably beneficial, as it checks the plant and all the bolls ripen off at the same time.

The Delta and Pine Land Company is one of the largest of the commercial seed breeders. They grow about 20,000 bales of $1\frac{1}{16}$ Upland of their improved types each year. In the past they bred $1\frac{3}{16}$, but they now find that the shorter staple is more profitable, as there is a greater demand for this type from the growers. Almost the entire profits of this concern are produced by the sale of the seed; the lint hardly pays for itself despite high average yields. This is a curious insight into the cotton-growing industry. The seed is put up into bags of 100 lb. each, and before it is bagged it is treated with Cerasan mercuric dust. This dusting results in a greatly increased germination percentage in normal seasons. The ginnery is a modern one, consisting of four air-blast saw gins. The seed cotton is taken from the delivery trucks by air suction, passed through the double opener to the gins in the same manner, and the lint is blown into the baling box. The ginned seed then passes through a de-linter, and is dusted and bagged. When the seed is not required for the de-linters after ginning it is conveyed to the seed store by an Archimedean screw. By these means the labour costs in the ginnery itself are reduced to a minimum. It is literally true that after the seed cotton has been placed in the delivery wagon or motor lorry it is never handled again; the baling press is

fed automatically and is fitted with a mechanical stamper or treader, and the seed is not touched until it arrives in the seed store.

The contrast between this type of ginnery with the roller-gin plants used in East Africa is marked. In the latter factories a large labour force is required to carry the seed cotton to the openers, to carry from the openers to the gins, to carry the lint to the press and trample it in, and to keep the under parts of gins clear of seed, all of which is carried to the seed store. Another marked contrast is the output capacity of the two types of ginnery. A four stand set-up of air blast saw gins, with 72 saws each, will turn out nearly 2,700 lb. of lint per hour—one gin of this type turns out one 500 lb. bale in 45 minutes—if working to full capacity. In Uganda, with a battery of fourteen 48-inch single roller gins (double-acting), only 800 lb. of lint per hour can be expected; out of fourteen roller gins there is usually one stopped for readjustment at any moment. It was stated in the United States that saw gins will keep in proper adjustment for six days' continuous running, provided the openers are functioning properly. The saws are sharpened at regular intervals; an ingenious machine recuts one tooth on each of the saws mounted on one spindle at a time, the spindle is then revolved slightly, and the next set of teeth are recut; thus this machine simultaneously recuts all the teeth on seventy-two saws. It is of interest to note that in the United States they experience no difficulty in ginning staple of full $1\frac{3}{16}$ or more with saw gins without damage to the staple. Only the American-Egyptian grown in Arizona and the Sea Island of Florida and South Georgia is ginned with rollers.

The Piedmont area

There are three chief soil types in this area: the Norfolk-Ruston soils in the Atlantic and Gulf coastal plains, and the Norfolk sands which divide the Norfolk-Ruston from the Cecil-Appling soils. The latter begin in north-central Virginia, extend across the Carolinas and Georgia, and end in eastern Alabama. In the southern part of the Cecil-Appling soil belt cotton is the dominant cash crop. Cotton, together with tobacco and groundnuts (peanuts), is one of the main cash crops of Norfolk-Ruston and Norfolk Sands soil belts. Under lengthy and exploitative cultivation, all three types erode badly. The Cecil-Appling area, locally known as the red-clay hill region of the South, includes the southern Piedmont. Very severe erosion was seen in this section.

The total annual precipitation varies from 40 to 55 inches, of which from 24 to 30 inches falls in the six warm months of April to September inclusive.

The estimated acre yields of the States of Alabama, Georgia, South Carolina, North Carolina and Virginia in 1938 were 220, 214, 240 and 200 lb. of lint respectively. The total estimated crop from these five States in that year was approximately three and a quarter million bales, the larger part of which was grown in the two southerly States of Alabama and Georgia. It is in these two States that a large proportion of the negro share-croppers are to be found.

Strip cropping and terracing are practised generally. To-day the Nichols type of terrace is the most popular. This consists of a broad-base bank with a settled height of about 18 inches and a broad shallow water channel on its upper side varying from 10 to 18 feet in width. The width of this water channel is determined by the steepness of the slope; the steeper the slope the narrower the channel. Examples were seen of narrow-base terraces which had been constructed many years ago in Alabama which had broken and resulted in severe gully erosion.

With the exception of the Sea Island grown in the southern part of Georgia, the remainder of the cotton area is confined to the cultivation of a number of Upland varieties. No one-variety communities were seen although the Bureau of Plant Industry maintains an organization for the setting up of one-variety communities at Atlanta in Georgia and at Raleigh in North Carolina.

The charges for ginning and baling in these five States are the lowest in the United States. The mean charges for the period 1929 to 1936 inclusive in Alabama, Georgia, South Carolina, North Carolina and Virginia were $3.46, $3.53, $3.27, $3.48, and $4.18 respectively per 500 lb. bale. The average bale output per ginnery of these five States is lower than the mean output for all the sixteen cotton-growing States. In tropical East Africa the cost of ginning and baling is reduced as the bale output increases. In the United States, it would seem that proximity to the Atlantic coast is the major factor in determining ginning and baling charges.

The Sea Island cotton of Florida and Southern Georgia

The Sea Island cotton is grown in areas with an annual total precipitation of from 50 to 60 inches, of which about 30 to 33 inches fall between April and September, and with an annual mean temperature of about 72 degrees

F. The frost-free period is about 300 days per annum, and in the southern part of the area killing frosts are infrequent. The soils are fertile and produce very good crops. In 1938, 14,800 and 11,900 acres of Sea Island were planted in Florida and Southern Georgia respectively. From this area about 7,000 bales of lint were produced. (Sea Island is usually put up in 375 lb. bales.)

In the past as much as 40,000 bales per annum were produced in Florida alone, and about 120,000 bales in the whole of the United States. As a result of the depredations of the boll weevil, Sea Island growing became almost extinct. During the period when this crop was not cultivated the U.S. Department of Agriculture kept a nucleus of seed running at their stations. In 1934, at the request of certain farmers and against the advice of the Department of Agriculture, the latter issued 50 bushels of seed of the Seabrook variety. These farmers undertook to keep this seed free from contamination with Upland cotton. In 1935 the 375 bushels of seed resulting from the 1934 crop were planted in 716 acres by farmers working under growers' agreements, and this resulted in 15,305 lb. of lint, which sold at 25 cents per lb. f.o.b. Providence, Rhode Island, for first quality, and 16 to 17 cents per lb. f.o.b. for second quality.

By 1938 the seed for planting was very largely grown in five counties, which had voted themselves one-variety communities under the terms of an Enabling Act passed by the Florida State Legislature. It is expected that in the near future a further fifteen counties will follow suit. The lint produced in one-variety communities is the property of the individual growers, but the seed cotton has to be ginned in the State-owned ginnery. The seed is sold for planting purposes, and the profits from this are returned to the growers. The five counties mentioned above produced sufficient seed for all the 1938 plantings from about 125 acres. It is difficult to make an estimate of the proportion of the crop which is planted with this "pure" seed, but it is hoped that the greater part of the total plantings will be made with such seed in the near future. Fields of Sea Island were seen growing close to Upland in the southern part of Georgia State, but it is hoped that with the extension of the one-variety communities this practice will be abolished. At the present time the majority of the growers realize the value of "pure" seed and are prepared to pay for it. The cost of seed for planting an acre was stated to be $1.75.

The average yield per acre is 100 lb. of lint. The commercial ginning percentage varies, with the soil and season, between 25 and 28 per cent.

The Government (State) has recently introduced six grades; the sixth grade is probably unsaleable.

The staple varies from $1\frac{1}{2}$ to $1^{15}/_{16}$ inches, with the average between $1\frac{5}{8}$ and $1\frac{3}{4}$ inches. Up to 1938, the lint buyers had only taken grade into account when tendering for the cotton; it is possible that staple length will become a factor in the future. On 13th September, 1938, No. 1 grade was selling at $26\frac{1}{2}$ cents per lb.; prices during the 1938 season varied from 18 to 30 cents per lb., according to grade. In a Jacksonville, Fla., newspaper of 12th September, a statement made by Mr. Nathan Mayo, Commissioner of Agriculture, to the Florida Sea Island growers included the remark that 25,000 bales per annum of this cotton could be used. Buyers who were present said they were prepared to purchase the whole of the crop provided they could be assured of a constant supply of good quality lint in quantities several times that now produced.

The successful continuation of Sea Island cultivation depends largely upon the success of the methods of controlling the boll weevil. The State agricultural authorities of Florida are fairly confident that the weevil can be controlled economically. At the time of the visit the plants were "mopped" at weekly intervals with calcium arsenate syrup up to the formation of the first square; after this, calcium arsenate dustings are made at weekly intervals. In addition, it is suggested that children should be employed to collect and burn all shed buds and plant trash.

It was stated that the cost of production in 1936 was a little less than $11 per acre (based on five farms), to which must be added $3.93 for ginning and baling and bagging seed. The average yield of these farms was 100 lb. of lint per acre. The cost of ginning and baling was more than 3 cents per lb. lint, while the average charge for saw ginning for the whole of the United States in 1936 was just over 1 cent per lb. This difference is due to the use of roller gins and the low ginning percentage of Sea Island. In return for the outlay of $11 per acre the growers received 28 cents per lb. of lint and $12.20 for 370 lb. of "pure" seed if sold for planting purposes. If the seed had been sold for oil expression at about $16 per ton, the return from this source would have been $2.96. Thus the ordinary grower who was not

in a position to sell "pure" seed made a profit of nearly $20 per acre in 1936. It will be noticed that there is no mention of the A.A.A. subsidy. The reason is that no subsidy is granted for cotton with a staple in excess of 1½ inches. Despite the lack of the A.A.A. subsidy growers of Sea Island can produce cotton and show a good profit; in this respect they must be, together with the growers of Pima in Arizona, unique as far as the United States are concerned.

The ginning industry

One of the greatest contrasts between conditions in the United States and East Africa is to be found in the organization of the ginning industry in the two areas. In East Africa the ginnery purchases seed cotton and then merchants the lint and seed; also, with few exceptions, roller gins are installed. In the United States, the ginneries are in fact ginning factories; they gin and bale the lint for the growers, and the latter, unless the lint has been sold forward to the ginnery to raise capital, sell their own lint. In the United States, the whole crop, with the exception of the couple of hundred thousand bales of Pima and a few thousand bales of Sea Island, is ginned on saws.

A visitor to the United States is immediately struck by the fact that ginning and baling charges are correlated with the world value of the lint. When lint prices go down, so do the ginning charges, although it must be admitted the reduction is not equivalent to the reduction in value of the lint.

As has been mentioned before, the major factor which determines the size of the ginning and baling charge is distance from the Atlantic coast rather than output per ginnery; as the distance from the Atlantic increases so the charges are increased.

The only long-term figures for the comparison of saw ginning and roller ginning costs which are available are for the State of Arizona.

Arizona: Period 1929 to 1936 inclusive.
Ginning and Baling Charges.

	Saw-ginned.	*Roller-ginned.*
$ per 500 lb. bale	6.20 ..	13.87
Ginning percentage in 1935	34.3 ..	26.1
	(Upland)	(Pima)

It will be remembered that the average ginning and baling for the whole of the United States for the same period was $5.00; so, if the whole of the U.S. crop was roller-ginned we might presume, using the Arizona figures as an index, that the ginning and baling charges would have been increased to $11.19 per 500 lb. bale. This is an increase of 224 per cent; i.e. roller-ginning costs more than twice as much as saw-ginning, if we do not take ginning percentage into account.

In the cotton belt, about half the gins are individually owned, about a quarter owned by partnerships, a further quarter owned by corporations. Only a few are owned co-operatively by the growers. Five different methods of assessing ginning and baling charges are to be found:—

(1) Charges based on the weight of seed cotton handled. Baling is an additional charge.
(2) A flat rate per bale which includes baling.
(3) Charges based on the weight of ginned lint. Sometimes the baling charge is extra; sometimes included.
(4) The toll system. The ginning and baling is done in exchange for a percentage of the seed cotton.
(5) Ginning and baling in exchange for a proportion of the seed; this proportion is determined by the value of seed at the time of ginning.

Generally speaking, the whole of the American crop could be ginned against the value of the seed. This is very different from the state of affairs ruling in East Africa, where it is often impossible for the ginner to export seed, as the market value is often below the cost of bagging and transporting the seed. In fact, some ginneries that are far from railhead can never export seed. If oil mills were established in East Africa it is possible that the value of the seed would increase, resulting in an increased price for the seed cotton, to the advantage of the African cultivator.

Acknowledgments

The writer wishes to express his gratitude to a number of gentlemen working in the United States Department of Agriculture and in the State Universities who were willing to give up their time and who supplied much of the information contained in this article. He is also indebted to Mr. Oscar Johnstone, of the Delta and Pine Land Company, of Scott, Mississippi.

References

[1] "Rates for Ginning and Wrapping American Cotton and Related Data, Seasons 1928-29 to 1935-36," by J. M. Wright and W. B. Lanham; published by Bureau of Agricultural Economics, Washington, D.C., 1937.
[2] United States Department of Agriculture, *Year Book of Agriculture*, 1938.
[3] *Atlas of American Agriculture*, Part II, Section A.

A SMALL FILTERING PLANT

By C. T. Cranswick, Nakuru

In view of the importance of the subject from the point of view of public health the comments of the Kenya Medical Department have been obtained and are included in an appendix. It will be seen that, while the filter improves a water supply, sterilization would still be necessary after filtration to ensure a safe drinking water.—*Ed.*

Recognized authorities state that charcoal filters are entirely inoperative, and that recent experiments have proved that the bacilli from enteric and cholera cultures pass freely through them into the filtrate. Military engineers in India have described charcoal filters as "veritable death traps". This is not so with sand filters, provided the maximum rate of about 500 gallons per square yard in twenty-four hours is adhered to.

The researches of eminent bacteriologists tend to prove that the bacteria in the lower layers of the sand become a "jelly", through which the water must pass, carrying with it neither solid particles nor poisonous germs, and that only when a filter is literally alive with micro-organisms that prey on organic impurities is its action really efficient.

A simple and inexpensive type of sand filter that has been in use on the writer's farm for some years, will be described for the benefit of those people living in isolated houses where clean or filtered water is unobtainable. The sketches illustrate the general principle, but to anyone interested in constructional details the following information will be of assistance.

A settling tank is an advantage. The unfiltered water should discharge into the lower half of this tank, and the outlet pipe, which leads to the filter tank, should be taken from the upper half. The size of the tank is immaterial, provided the capacity is sufficient to allow the coarser sediment to settle before the water enters the filter tank.

A filter tank for a household using very impure water should be about 5 ft. round or square by 6 ft. high (internal dimensions), but a smaller one may be used if the water is comparatively clean. One corner should be walled off, and a 3 in. square aperture left in the bottom of the partition wall. The floor of the tank should have a slight slope towards this aperture.

On the bottom of the tank two courses of 3 in. flooring stone should be laid, the upper course covering the interstices in the lower one. Porous stone is an advantage, though not necessary. These two layers of stones must not be cemented, but laid loosely on the floor of the tank. They act as a drain from the filtering medium to the outlet pipe, and in practice do not impede the passage of the filtrate.

Above these stones place layers of the filtering medium in the following order: 4 in. gravel the size of walnuts, 4 in. gravel the size of beans, 4 in. gravel the size of peas, and finally 3 ft. of sand. All should be washed and screened.

The outlet pipe should be fixed inside the partition chamber, about 1 ft. 6 in. from the bottom of the tank, and led through the wall above sand level. Alternatively, if an existing tank is to be utilized, just a pipe without any partition chamber may be used for drawing off the filtered water, though for obvious reasons this is not so satisfactory.

The inlet water should enter the filter tank through an inverted bell-mouthed orifice, fixed at high water level, the flow being controlled by means of a $\frac{3}{4}$ in. ball-valve.

To clean the filter, remove the top two inches of sand every few months, or whenever it is considered to be necessary, and wash or replace. It will be found that practically all the solid particles come to rest in the top two inches of sand.

Dependent on the amount of impurities in the water, it will be necessary to clean the whole of the filtering medium every year or two.

APPENDIX

By Kenya Medical Department

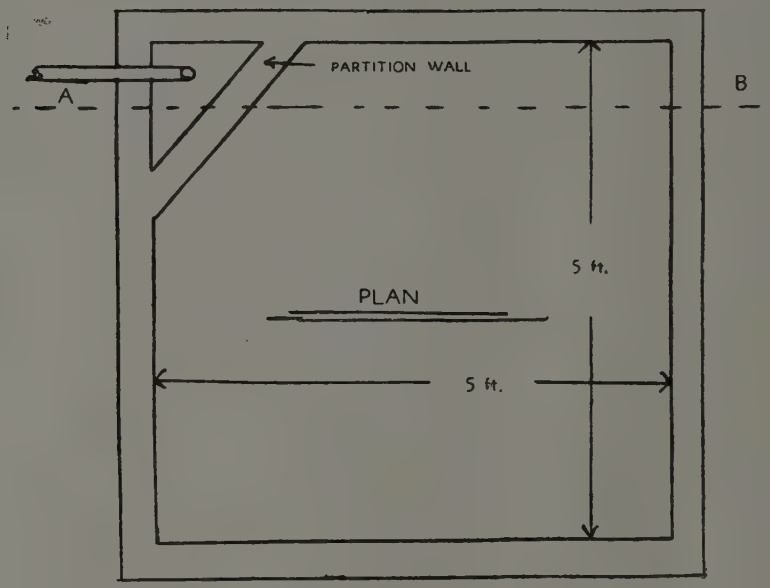
It is considered that the sand filter design illustrated by Mr. Cranswick would, in general, be effective in reducing silt in suspension in turbid waters, and would, if sufficiently "ripe", remove micro-organisms and a high percentage of the bacterial content, but it would be inadvisable to assume that the filtrate would be bacteriologically safe under all conditions or with all waters.

Most surface waters in this country are grossly polluted, and the removal of a high percentage of the bacterial content may be insufficient so to prevent the passage of pathogenic germs as to ensure complete safety against water-borne diseases. Cercariae, the infecting agents of Schistosomiasis, are capable of penetrating a layer of thirty inches of filter sand, and only a subsequent storage of not less than forty-eight hours would prove satisfactory. Storage of the filtrate is also considered essential in order to ensure uniformity or flow in the filter bed, i.e. direct draw-off from the filter is eliminated.

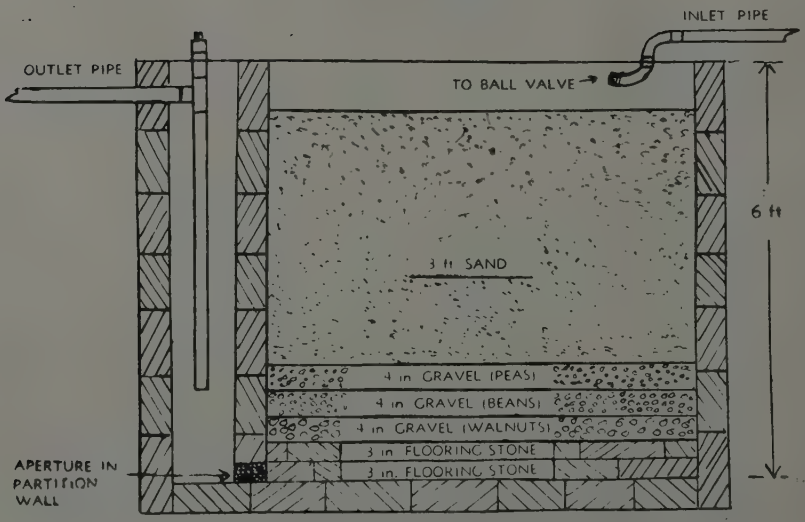
The rate of filtration, 500 gallons per square yard in twenty-four hours, is high, and it is recommended that this should be considerably reduced.

Whilst appreciating that the filter would be a cheap means of improving a small water supply, it is stressed that sterilizing by boiling, or other means, after filtration, is absolutely essential to guard against water-borne diseases.

SMALL SAND FILTER



SECTION THROUGH TANK A–B



THE NUTRITIVE VALUE OF SOME TANGANYIKA FOODS

I—THE BANANA

By W. D. Raymond, B.Sc., Ph.D. (Lond.), F.I.C., and W. L. Jojo, B.Sc. (S.A.), the Chemical Laboratory, Dar es Salaam

(*Received for publication 8th August*, 1940)

Owing to the important position of the plantain in the dietaries of some African tribes and the variations which exist in published analyses we decided to perform analyses of Tanganyika material obtained from a banana-eating area (Bukoba) and to attempt to select from our analyses a representative figure which can be used in calculations involving Tanganyika material. Most of our figures are based on quadruplicate or in some cases duplicate analyses made on four samples of mixed varieties received from Bukoba. As soon as possible after receipt the several varieties were skinned and mixed in a mincing machine. The mixed material was divided into two and in every determination two separate samples were taken. This enabled us to decide what degree of uniformity had been achieved in the sampling. In some cases where there were objections to the above procedure, the method employed is indicated in the text below. It thus follows that many of the mean analyses are based on sixteen separate determinations.

Before giving our results it will be useful to describe the African method of classification of the varieties of banana in use in Bukoba. The bananas are divided there into three main classes (a fourth class, *Migomba ya sukari*, is described by Culwick (1940) as mostly sold for non-native consumption):—

(1) *Gonja.*—A banana with triangular section, used ripe whether for roasting or boiling. It is eaten separately from the main dish. According to Culwick, this class, together with the *migomba ya sukari*, only represents about 3 per cent of the total Bukoba crop.

(2) *Vitoke* (*ebitoke*).—A soft, round and fairly sweet fruit. Used unripe exclusively for cooking with meat, fish, bean and other relishes.

(3) *Mbire.*—A somewhat bitter banana, used mainly for brewing beer.

In the present work a mixed sample of various cooking and roasting varieties of bananas, and then three separate mixtures of Gonja, Vitoke and Mbire respectively were received. As far as ascorbic acid and vitamin A (carotene) are concerned, separate analyses of each variety (in duplicate) were made. The following are the actual varieties examined in the present work:—

1. *Gonja*: Nkungu, Mtamaga, Chayaya, Mkono wa tembo.
2. *Vitoke*: Ntobe, Nshakara, Nkukumwa, Ndekula, Nyoya, Njubo, Ntaragaza, Nchoncho, Nbururu, Nzirabaima.
3. *Mbire*: Nshasha, Ntai, Ntobe, Nsanshabiri, Nkira, Nshaka, Nkundakundi.

According to Stuhlmann (1909) Group No. 1 is *Musa paradisiaca normalis* and Groups Nos. 2 and 3 are *M. paradisiaca* var. *sapientium.*

Water content

The water content was determined by McCance's method, and although the method is not entirely free from objection, good agreement between duplicates was obtained. Our mean results are as follows: Gonja, 66.79 per cent; Vitoke, 77.02 per cent; Mbire, 68.84 per cent. Mixed cooking, 72. 83 per cent. Mean for all analyses, 71.21 per cent. McCance found 70.7 as a mean for four analyses. Pollard gives 71.8 to 74.8 as typical figures. We propose 70 per cent by weight as a representative figure. The water content of the banana does not appear to vary greatly.

Carbohydrate

Our methods have been those of McCane, namely hydrolysis of starch with taka diastase and direct determination of sugar by its copper-reducing power. In selecting a value for the carbohydrate content the ripeness of the fruit has to receive consideration. Pollard (1937) gives the following as the average carbohydrate content (expressed as a percentage of dry matter) of the banana:—

	Starch	Sucrose	Reducing Sugar
	Per cent	*Per cent*	*Per cent*
Green ..	64–74	0·0–0·4	0·0–1·8
Ripe ..	5·2–14·5	6·6–30·1	20–40

In the present work covering bananas in various degrees of ripeness, our figures have covered the following range:—

Sucrose	3·6–27·1	per cent of dry matter
Reducing sugar ..	2·9–34·4	„ „ „
Starch	4·4–62·4	„ „ „

Our mean figure for total carbohydrate was 69.1 per cent, and a representative figure of 70 per cent (expressed on a dry matter basis) is selected.

Fat

This is so small as to have little significance. We found a mean of 0.16 per cent of digestible fat in two samples examined (method of McCance).

Protein

This was determined in the usual manner as nitrogen and multiplied by 6.25 to give protein. An average figure of 1.3 per cent is selected to represent the material (variations found, 1.07 to 1.44).

Mineral content

The following table gives the maxima, minima and mean value for the elements determined (expressed as a percentage of the wet matter):—

	Max.	Min.	Mean	
Ash (approx.) ..	—	—	1·0	per cent
Phosphorus (P)	54·74	43·05	47·1	mgms per 100 g
Calcium (Ca) ..	4·90	4·17	4·65	ditto
Iron (Fe) ..	—	—	0·36	ditto
Magnesium (Mg)	38·62	28·80	33·8	ditto
Potassium (K)..	536·8	418·1	469·0	ditto
Sodium (Na) ..	Very low—order of 1 mgm.			

Note.—The figure for iron is based on two samples only. Other figures for iron in bananas put through the mincing machine showed up to 1.77 mgm/100g due to iron derived from the machine (see McCance *loc. cit.*). The sodium was too small to estimate with accuracy in the presence of the large amount of potassium.

Most of the methods were those of McCance, although certain modifications were made in the method of determining potassium.

McCance determines potassium by precipitating the element as the cobaltinitrite and titrating the precipitate with standard potassium permanganate. We have preferred to estimate the potassium in the precipitate by treating it with sulphanilic acid and alpha naphthylamine with a colorimetric determination of the red amino azo compound produced. Satisfactory recoveries of added potassium were obtained and a standard solution checked against a known solution containing half its amount of potassium gave a factor 0.505 (theory 0.500). The reagents were prepared according to the directions of Feigl (1938).

Oxalic acid

Majumdar and De (1938) reported an oxalic acid content of the unripe plantain ranging from 517 to 524 mgm. per cent. Since the diet of the Bahaya is often almost exclusively derived from the unripe plantain (with a calcium content of about 5 mgm. per cent), this would mean practically no calcium was available to them. The effect of oxalic acid in preventing the absorption of calcium by forming insoluble calcium oxalate has been well established, and since the Bahaya continue to exist on the plantain as staple the Indian figures are at once suspect. Berntraeger (Wehmer, 1929) found no oxalic acid in the unripe banana but gallic acid and tannins have been reported. The method adopted by Majumdar and De was to extract the material with hydrochloric acid and to precipitate the oxalic acid as its calcium salt in acetic acid solution. Under these conditions we obtained a large almost black precipitate which qualitative tests showed contained little calcium oxalate (tests: Rescorcinol test, anilin blue reaction, glyoxylic acid test). When this black precipitate was treated with 2N sulphuric acid, filtered, treated with sodium carbonate, again filtered, neutralized and precipitated with calcium sulphate, only a slight precipitate was obtained. Dissolved in 2N sulphuric acid on the filter paper, the filtrate was titrated with standard permanganate. The amount of oxalic acid found amounted to 1.3 to 2.2 mgm. per 100g. banana. This precipitate gave a positive reaction in the glyoxylic acid test, but we do not claim it was pure calcium oxalate. We therefore concluded that the unripe bananas contained only traces of oxalic acid.

Vitamins

We have been able to include figures for carotene and ascorbic acid determined on all varieties received.

Our method of determining ascorbic acid has followed the now well-known micro titration with 2:6 dichloroindophenol, using metaphosphoric acid for the extraction of the sample.

Our indicator solution was frequently checked against titrated ascorbic acid or ferrous ammonium sulphate, the latter in turn being checked against ascorbic acid of known strength.

Carotene was determined by saponification with alcoholic alkali and subsequent washing of a light petroleum ether extract, first with water until all alkali was removed, and then with 90 and 95 per cent methyl alcohol successively to remove xanthophyllic pigments. The resulting depth of colour was measured in a Pulfrich photometer using a S 47 filter. The carotenoids so measured would include all the carotenes as well as crytoxanthin and lycopene. The last-named is biologically inert.

In order to separate the carotenes from the lycopene we found that under certain conditions a short column of alumina oxide would absorb the lycopene and cryptoxanthin but allow alpha and beta carotene to pass through. The results of quantitative determinations made by this method are given below:—

	Percentage total carotenoids unabsorbed under given conditions
	Per cent
Mixed alpha and beta carotene	97·3; 101·7
Tomato (epiphasic carotenoids)	45·5; 48·0
Mixed banana (epiphasic carotenoids)	97·5

We conclude that the epiphasic carotenoids of the banana consist mainly of alpha and beta carotenes. This seems to agree with the work of Lanzing and Van Veen (1939). On the other hand, Leong (1939) has suggested that the provitamin A content of the banana is only two-fifths times its epiphasic carotenoid content. The factor is based on biological experiments. Since in this work a standard solution of beta carotene was employed as a reference, and beta carotene is about twice as active physiologically as the alpha or gamma carotene, this finding would suggest the presence of an appreciable amount of some inactive carotenoid in the mixture. An alternative explanation suggests itself. It is that the standard beta carotene, probably fed in oil, was much better absorbed than the carotene present in the almost fat-free banana, and that this better absorption caused the factor to be incorrectly low.

Some support for this explanation exists in the observations of Culwick, who found the Bahaya, with a high carotene intake and a daily fat intake of only a few grams, showed signs of vitamin A deficiency. Using the figure of 500 micrograms carotene per 100 g. of banana, the estimated daily intake by these tribes is about 10,000 micrograms.

The following are the results obtained by us. Each figure represents the mean of at least two fairly closely agreeing determinations:—

Variety	Ascorbic mgm/100g	Carotene Micrograms per 100g
Dar es Salaam—		
Mzuzu	18·3–12·1	400 green unripe
*Ngazija ..	20·0	45 „ „
Gonja—		
Nkungu.. ..	18·2	945 partially ripe
Mtamaga ..	13·7	950 „ „
Chayaya ..	16·1	1,022 „ „
Mkono wa tembo	17·7	800 „ „
Vitoke—		
Ntobe	11·6	126 green
Nshakara ..	9·8	624 „
Nkukumwa ..	19·5	532 „
Ndekula ..	9·6	272 „
Nyoya	16·7	874 „
Njubo	9·8	898 „
Ntaragaza ..	10·1	570 „
Nchoncho ..	9·5	314 „
Nbururu ..	10·4	633 „
Nzirabaima ..	9·6	359 „
Mbire—		
Nshasha ..	34·2	13 „
Ntai	12·3	352 „
Ntobe	15·6	20 „
Nsanshabiri ..	16·3	262 „
Nkira	14·4	130 „
Nshaka	11·5	393 „
Nkundakundi ..	16·8	128 „

*Ngazija stored 5 days till ripe, 15·4 mgm (stored at room temperature 27°C.).

It will be of interest to compare these results with other values recorded. Fixsen and Roscoe's table records ascorbic acid figures of from 1 to 15 mgm./100 g. for the banana (*Musa sapientum*) and 5.5 to 156 mgm./100 g. for the plantain. Ranganathan (1935) found 23.9 mgm./100 g. Our own figures do not show a wide variation, since all the rounded figures except one fall within the range 10–20 mgm./100 g. We think the figure of 14 mgm. can be taken in calculations involving local material without great error.

The figures for the carotene content of the banana may be compared with recent work done in Malaya and Java on various local varieties there. Unfortunately, little is known regarding the connexion between the local Malayan varieties and our own. Stuhlmann thinks that our *Mkono wa tembo* is close to their Horn Plantain (*Pisang Tandok*). Leong found a (total) carotene content in this variety of 780–1035 as compared with our 880 micrograms/100 g. His mean figures show a range

(due to all varieties) of from 45–1050 micrograms/100 g. (Leong, 1939). Lanzing and Van Veen's results for Java show a range (for all varieties) of 11–1500 micrograms/100 g. Our results cover the range 13–1022 micrograms/100 g. These results are in close agreement. It is obvious that the carotene content of the banana varies so much with variety as to exclude the use of any representative figure. Nevertheless, as far as the Bahaya are concerned, their food banana (as distinct from the beer banana) are derived mainly from the *Vitoke* class, which only vary from 126–898 micrograms carotene/100 g. (mean 520). A figure of 500 micrograms/100 g. can probably be used without great error in calculations extending over several individuals.

Representative value

We suggest that in calculations involving Tanganyika material (skinned fruit) the following representative figures may be used without serious error:—

Water	70	gms/100g.
Carbohydrate ..	21	,,
Fat	0·2	,,
Protein	1·3	,,
Calcium (Ca) ..	4·6	mgm/100g
Phosphorus (P) ..	47·1	,,
Iron (Fe)	0·4	,,
Ascorbic acid ..	14	,,
Carotene	500	micrograms/100g (for Bahaya)
Calorie value ..	91	per 100g

Summary

Analyses of different varieties of the Bukoba local plantain have been made for fat, protein, carbohydrate, phosphorus, calcium, iron, magnesium, potassium, sodium, oxalic acid, ascorbic acid and carotene. Representative values have been selected for use in calculations involving the food intake of those East African tribes which utilize bananas as a staple. The methods of analysis are briefly described. Analytical modifications devised by the authors include the colorimetric determination of potassium using the Greiss reagent and the photometric determination of carotene after separation from lycopene by passage through a short chromatogram of Merck's alumina oxide (prepared according to Brockmann).

We thank Mr. T. S. Jervis for providing us with representative material for analysis and for notes on the classification of bananas by the Bahaya, and the Director of Medical Services, Tanganyika Territory, for permission to publish this work.

REFERENCES

Culwick, A. T. and G. M. (1940).—"Nutrition and its context in Bukoba" (in mss).

Fixsen, M. A. B. and Roscoe, M. H. (1938).—"Tables of the Vitamin Content of Human and Animal Foods, *Nutrition Abs. and Reviews*, 7, 823.

Feigl, F. (1938).—*Qualitive Analyse mit hilfe von Tupfelreaktionen* (3rd Edition).

Leong, P. C. (1939).—"Vitamin A content of Malayan Bananas", *J. Malaya Branch B.M.A.*, 3, 156.

Lanzing and Van Veen (1937).—*Geneesk. Tijdschr. Neder. Indie*, 77, 2777.

McCance, R. A., Widdowson, E. M., and Shackleton, L. R. B. (1938).—*The Nutritive Value of Fruits, Vegetables and Nuts*, H.M. Stat. Office, London.

McCance, R. A. and Shipp, H. L. (1933).—*The Chemistry of Flesh Foods and their losses on Cooking*, H.M. Stat. Office, London.

Majumdar, R. N. and De, N. K. (1938).—*Ind. J. Med. Res.*, 25, 671.

Ranganathan, S. (1935).—*Ind. J. Med. Res.*, 22, 239.

Stuhlmann, F. (1909).—*Beitrage z. Kulturgeschichte v. Ostafrika*, p. 54.

Thorpe, J. F. (1937).—*Dictionary of Applied Chemistry* (4th Edition), Vol. 1: Article, "Banana", by A. G. Pollard.

Wehmer, C. (1929).—*Die Pflanzenstoffe*, I, 174.

THE RESPONSIBILITIES OF THE SCIENTIFIC WORKER

Scientific workers have yet to realize that they have a very large responsibility for seeing that much more adequate use is made of the knowledge which they have made available for the community. They must assist much more wholeheartedly in the interpretation of those results to the community, whether to the administrator or to the general public, in order to secure their integration into the general policy and practice of the community. . . . . Men of science should recognize that concern with the social consequences of the application of their discoveries involves attention to the way in which these discoveries are presented to the public, in order to secure as favourable an opportunity as possible for the use of new knowledge for society's weal rather than its woe.—*Nature*, Vol 146, 1940, p. 2.

SOME OBSERVATIONS ON POULTRY

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab.)

(Adapted from the 1938 Annual Report of the Veterinary Department, Tanganyika)

Poultry husbandry has been included in the scheme of work at Mpwapwa for a number of years, and the underlying principle has been the improvement of fowls for all sections of the community. The results discussed below are taken from the work designed to help European farmers. Pure breeds of Rhode Island, White Leghorn, Light Sussex, and Silver and Golden Cambars are maintained, but these observations are confined to the first two breeds, because insufficient data have been collected for the other types.

Egg production has been the aim in this work for Europeans, because such farmers will probably not compete so successfully with natives in the production of table birds, except for specialized markets.

Egg records

All birds in the government flock are trap-nested and complete records are kept of the weight and yield of eggs. The first generation of birds bred from imported pure-breds have given egg yields much above those of the originally imported birds, although these latter were from good egg-laying strains. It appears that when brought from England these pure-bred birds take some time to become acclimatized and consequently their egg yields are below their real potential capacity.

The second generation of birds bred in this country have maintained the high average egg production in the Rhode Island breed, but in the White Leghorns there have been a number of bad failures. The egg weights have been good in the imported and first-generation birds, but in the second generation, although the egg size has become normal eventually, there is a tendency for the pullets to lay small eggs for a longer period than is usually expected. The egg records are given below, but the figure for the second-generation White Leghorns does not include a number of birds which have completed their first laying year but which have proved extremely bad layers.

First-generation Rhode Island Reds have averaged 227 eggs in their first year.

First-generation White Leghorns have averaged 230 eggs in their first year.

Second-generation Rhode Island Reds have averaged 214 eggs in their first year.

Second-generation White Leghorns have averaged 186 eggs in their first year.

The egg weights have averaged 58.5 gm. and 55.9 gm. for the first generation White Leghorns and Rhode Island Reds respectively. In the second generation these averages have been 55.1 gm. and 55.6 gm.

Moulting is not confined to any particular period of the year, but if it occurs between January and April it tends to be protracted (during the wet season). This protracted moulting period occurring, as it usually does, at the end of the first laying year seriously reduces the egg yield in the second year. A few cases have been observed in which moulting birds have become sunburnt and their backs have been very red and inflamed.

The egg yields in the second laying season are considerably below those in the first season as indicated by the following average figures for birds which have completed two laying seasons: Rhode Island Reds laid 227 eggs in the first season and 153 eggs in the second. White Leghorns laid 250 eggs in the first season and 148 eggs in the second. Great variations exist between individual hens, and first-year yields are no indication as to what can be expected in the following season. In the third laying season there is a further drop in egg production.

Experience at Mpwapwa has indicated that the White Leghorns mature slightly earlier than Rhode Island Red pullets, but the differences in the size and yield of eggs are not significant. It also seems that the particular strain of White Leghorn does not possess such a robust constitution as the Rhode Island Reds.

Seasonal variations in egg yields

The yield of eggs is subject to seasonal variations and the figures given in Table I give the average monthly yields per bird. These figures were obtained from seventy-five Rhode Island Reds and twenty-five White Leghorns whose combined average yield is 228 eggs in their first laying year. The figures apply only to first-season productions of birds commencing to lay between December and June. It is unfortunate that records are not available for birds beginning to lay in the latter half of the year, but there are very few such birds in the flocks. Although the figures for the White Leghorns and Rhode Island Reds are combined, the figures for these individual breeds show exactly the same general tendencies, and nothing would be gained by showing each

breed separately. In this table are also given the average daily maximum shade temperatures for each month during the period of this study and the average hours of sunshine each day for each month.

TABLE I
Seasonal Variations in Egg Yields, Hours of Sunshine and Maximum Shade Temperatures

	Average monthly egg yield	Average hours of sunshine per day	Average maximum shade temperature Fahrenheit
January ..	18·00	8·45	82·4°
February ..	15·45	6·75	84·2°
March ..	15·62	6·45	80·6°
April ..	14·18	5·95	78·8°
May ..	15·60	5·15	75·2°
June ..	20·98	8·45	77·0°
July ..	21·88	7·95	77·0°
August ..	22·26	8·55	77·0°
September..	21·66	9·60	80·6°
October ..	20·32	8·85	82·4°
November..	18·68	7·60	86·0°
December..	18·09	7·20	84·0°

It will be seen that the monthly egg yields rise sharply from May to June and then fall slowly from August to November. There is a further smaller fall from January to February, with the lowest figure in April.

The egg production depends upon a number of factors, such as hereditary potentialities, nutritional plane, breed and age of the birds, and freedom from disease, all of which are not affecting the present study of the seasonal fluctuations. Actually, these hens were all bred from birds imported from England, and represent the first generation bred in this Territory. The imported birds were from good egg-laying non-broody strains. The hens recorded here were all of approximately the same age when they commenced laying (five and a half to six and a half months old), and all were fed a good balanced ration capable of meeting their productivity without drain on their body tissues. The birds were confined to grass runs which allowed ample space for each bird and the eggs were all recorded by trap-nesting.

It is seen that the maximum egg yields are obtained in the first two-thirds of the dry season when the grass was drying off and insects were fewer. The availability of young green grass is thus not responsible for any increase in the production.

It is generally recognized, particularly outside the tropics, that there is some connexion between the light ration and egg yields, and increasing amounts of daylight are usually followed by increased production. Whetham (*J. Agric. Sci.*, 23 (1933), p. 383) has studied the effect of light on egg yields, and points out that it is the change in the amount of light rather than the amount of light itself. She shows that as one travels from the tropics to the poles the egg production curve becomes steeper and follows the curves of "length of daylight" much more closely. The two curves she produces for production in the tropics (at 10° N. and 20° S. latitudes) differ from those of temperate latitudes in showing less seasonal variation and in not corresponding so closely with the daylight curves. She points out that in these two cases the variations in the hours of daylight are very small and other factors will play a more dominant part.

Since changes in the quality of light, acting by way of the pituitary organ, are of such great importance, it was decided to compare the productivity of the hens with the actual hours of sunshine, because in the tropics the hours of sunshine vary more than the hours of daylight. When these two curves are compared it is at once seen that there is some close resemblance in shape. The trough of the egg production curve occurs at the time of the lowest insolation rate, and as the hours of sunshine increase so does the egg yield. The curves do not correspond exactly, but there is an undoubted resemblance in their shape and, though the change in the daily amount of sunshine does seem to affect the level of egg production, this does not seem to be the only controlling factor governing seasonal production under the experimental conditions.

The effect of temperature was next examined. Whilst it is true that the maximum egg yields are obtained in the cool period of the year, and that as the temperature increases the egg yield drops, there is no corresponding gradual rise in production as the temperature falls. Instead there is a *sudden* increase in the egg output in May after the cool season has definitely commenced. Temperature therefore does not act directly upon egg production.

In the hotter weather these European birds shelter in the shade during the heat of the day and stand panting with their beaks open and their wings lifted from their bodies in their efforts to keep cool. This is very reminiscent of the efforts of high grade and pure bred cattle to keep cool (French; Ann. Rep. Vet. Dept., Tanganyika, 1937, p. 71), and just as European cattle suffer from the heat it is possible that hens are similarly affected. Because they are more out of harmony with the hot conditions, appetite may be lowered at this time and productivity decreased. Then when the cool season comes along they would be more active, would eat more and lay more

eggs. The temperatures of our cool season compare more closely with the summer conditions under which these breeds were developed to their present high state of production, and consequently the birds would be more in harmony with their environment at this time.

Egg yield variations due to season at which birds commenced to lay

If the records are examined it is found that the birds which commence to lay in December or April give higher average first-season egg productions than birds beginning to lay in other months of the interval December to June. Table II gives the average values so far obtained:—

Table II

Average Egg Yields of Birds Commencing to Lay in Different Months

	Rhode Island Reds	White Leghorns
December	232	275
January	217	225
February	217	226
March	219	246
April	248	256
May	229	216
June	220	212

No figures are available for birds beginning to lay in the months July to December. This is merely a chance happening and is not caused by environmental or other causes.

How to get maximum egg yields

Further important questions which have been engaging attention are the best way to get maximum egg yields during the life of the hens, and at what age does a bird become uneconomical to feed? It was uncertain whether very heavy production in the first laying season would put too much strain on the birds in our climatic conditions, and so result in reduced yields in subsequent years. I have always aimed at high egg yields in the belief that if a bird is capable of high production over a prolonged period she must possess the necessary good constitution, otherwise breakdowns would have occurred. Actually, the results obtained indicate that high production in the first year does not necessarily interfere with the egg yields in subsequent years, and a low producer is just as likely to reach an uneconomic level of production in her second laying season as a good layer. With very heavy laying birds the risk of death from ruptured oviduct or other troubles in the reproductive organs is greater than in the case of normal layers. The question is continually being asked as to whether it would not pay to aim for a lower egg yield and so reduce this risk. The experience here so far does not support this, because a ruptured oviduct, etc., occurs just as frequently in medium layers as in good hens, and some hens which have died from this cause have been very bad layers indeed. Thus, though the risk of death from a ruptured oviduct must be greater with greater productivity, I do not think we should aim at lower-producing birds to minimize this risk. The tendency to degenerate in European stock is so great in this Territory that I believe every effort should be made to keep up the standard of the departmental birds; they will drop quickly enough in productivity after issue and distribution.

At the moment, I am aiming at a level of production of four hundred eggs in two years for the breeding pens, my argument being that this is an economic level of production and the hens' constitutions must be good otherwise they would have died before completing two years. So far I have not worried whether the four hundred is reached by heavy production in the first year or by more steady production over two years. The only drawback to this plan is that these old birds give eggs of lowered fertility, but I am hoping that a smaller number of progeny from tested birds will be better than a larger number from unproven hens.

The question of fertility is still further complicated by close in-breeding. Owing to the expense involved, this department made the grave mistake of ordering too few birds from England. All the present flocks have been derived from one cock and three hens of the White Leghorn breed and the same thing has happened with the Rhode Island Reds. Although the cocks were not related to the hens, the hens were related to one another. It is most important when starting a new venture such as this that this error is not made, and attention has been drawn to this point to warn others. With the White Leghorns, as mentioned above, there are a large number of these in-bred pullets which are failing badly as egg machines. In-breeding is the breeder's most potent weapon, but if used too soon or without proper care it can concentrate bad characters instead of the good ones.

Tests have been made on the fertility of the eggs from both breeds, and variations have been large—34 to 89 per cent. It has been noticed that some hens have given consistently low results with certain cockerels whilst, at the

same time, other hens in the same pen have given normal fertility rates. A change of cockerels has also produced big changes in the fertility rates, and it appears that, where large flocks are kept, a certain amount of selection takes place between the hens, and the cocks never or only occasionally visit certain individual hens.

The percentage figures for *hatchability* and *viability* vary considerably between individual hens and between different seasons. Usually we expect seventy per cent for hatchability, but during recent months this level has rarely been reached. For viability percentages it is hard to say what we regard as normal, because epidemics of roup have seriously reduced our average figures. As an example of the variations obtained between individuals the following are quoted at random:—

Hen 228 has given 77 per cent living chicks with Cock 28.

Hen 224 has given 24 per cent living chicks with Cock 28.

Hen 35 has given 0 per cent living chicks with Cock 28.

Hen 1 has given 0 per cent fertility with Cock 1207.

Hen 184 has given 76 per cent fertility with Cock 298.

Hen 128 has given 82 per cent fertile eggs hatching with Cock 463.

Hen 151 has given 5 per cent fertile eggs hatching with Cock 295.

When is the best time for hatching?

Experiments are still in progress to measure the rates of growth and maturity of chicks of both the above pure European breeds. It is hoped that eventually we shall be able to say which is the best month for hatching to take place so as to get the greatest growth rates and egg yields combined with the lowest mortality rates. It is early yet to give a definite opinion on this question, though it seems that chicks hatched between June and October do better and grow faster than those hatched at other times of the year. This management also fits in with the observed effect on egg yield of the time of first beginning to lay (see above).

Feeding costs of egg production

This department considers that feeding is one of three essentials that must be carefully studied if poultry keeping is to be economically successful. It has been calculated that with our standard laying ration of maize, millet, bran, groundnut cake, meat meal, bone meal and salt, the feeding costs from the 1st November, 1937, to the 31st October, 1938, have been Sh. 637/17 for the production of 19,941 eggs; that is 3.19 cents per egg. The feeding costs average 3.20 cents for the White Leghorn eggs and 3.16 cents for the Rhode Island Red eggs. This difference is not significant, and is probably due to the greater percentage of food wasted in feeding the smaller flocks of White Leghorns.

The labour bill was Sh. 360 for this period, but the two boys employed trap-nested the birds, kept the records, weighed the individual eggs and ran the incubators and brooders. For a commercial flock this wages bill could be reduced below the 1.8 cents per egg on the Government farm.

Indoor battery system of management

With the great intensification of farming in temperate regions the intensive battery system of poultry management has developed. There is no reason to expect the adoption of this system in this Territory except in towns where a shortage of eggs is very marked. Also such an indoor battery system would not only minimize space on the ordinary farm but would also reduce the risk of losses from vermin, theft and diseases.

Trials were made with White Leghorn and Rhode Island Red fowls and the results are summarized as follows:—

Table III

Average Egg Yields of Pullets under Battery and Range Systems

Breed	On range management in closed runs	Put into indoor batteries before commencing to lay	Put into indoor batteries after starting to lay under range conditions
White Leghorn ..	118 in 6 mths.	86 in 6 mths.	38 in 6 mths.
Rhode Island Reds ..	77 in 4 mths.	44 in 6 mths.	32 in 4 mths.

The birds used in this study were fed the standard laying ration and those inside got the same mixture and green foods as those in open runs. It is most clear from these results that the indoor battery system of management is a failure in this Territory. It is interesting to observe that a similar result has been recorded in Palestine.

Birds which have started to lay under range conditions fare much worse in the batteries than pullets which are put into the cages before starting to lay.

In spite of the cages being fitted with perches a lot of leg troubles developed. The condition

produced was a paralysis of one leg, and it often took a long time for the birds to recover after they had left the cages and even then complete recovery was not attained. Also it is interesting to note that the affected birds went off egg production completely and often went for a long time before they commenced to lay again. All birds that had been in the batteries laid badly for a long time after removal from the cages to open runs.

Obviously the battery system of management cannot be encouraged.

Feeding trials

Experiments have been undertaken to work out the cheapest and most efficient poultry rations for this Territory. These trials have been carried out under normal husbandry conditions and are therefore directly applicable.

In this Territory shortage of protein characterizes the rations of most classes of farm live stock, and poultry are no exception. The protein concentrates, and especially those of animal origin, are expensive and there is a natural tendency on the part of farmers to try and economize on these foodstuffs. This is a very false economy, and proteins must be fed in adequate amounts if economic returns are to be obtained.

Protein concentrates of animal origin are not only expensive but have to be transported long distances, and transport charges are particularly high. Many farmers therefore try to avoid this group of foodstuffs and rely upon those vegetable protein foods which can be grown on the farm or purchased locally. This point is of such importance that it was decided to run an experiment to test the comparative values of rations with and without animal protein in their make-up. This was considered very necessary because it has been evident that, when through shortage of supplies meat meal has been omitted from our normal laying ration, egg yields have decreased.

Two rations were designed to provide the same quantities of digestible protein and starch equivalent values, but one was composed entirely of foods of vegetable origin whilst the other contained meat meal. These rations were composed as follows:—

	Group 1	Group 2
Maize Meal	48	26
Bulrush millet (Mawele) ..	19	26
Groundnut cake	12	20
Rice polishings	12	12
Beans	—	13
Meat meal	6	—
Lime	2	2
Salt	1	1

For the feeding trial two pens of Rhode Island Red pullets, each containing twenty-five birds, were established to be as similar as possible. The trial lasted for six months, and the results were as follows:—

	First three months	Second three months	Total for six months
Group 1 ..	1,358 eggs	1,046 eggs	2,404 eggs
Group 2 ..	1,203 „	685 „	1,888 „

These egg yields show that, to begin with, there was little difference in the egg yields from the two pens, but as the trial progressed the birds receiving no meat meal lagged further and further behind those getting meat meal. This difference was becoming more pronounced as the trial continued. Over the six months it is seen that the non-meat-meal group laid 21.5 per cent less eggs than their neighbours, and this is sufficiently great to indicate that the meat meal ration is a much more efficient laying mixture.

On this station it is sometimes the practice to feed boiled meat to the fowls, and it was decided to continue the above experiment, but adding equal amounts of boiled meat to each group. The quantities fed varied between one-ninth and one-third of a pound per hen per week, and the following results were obtained over a five months feeding period:—

Group 1 laid 2,272 eggs, averaging 2.50 ounces each.

Group 2 laid 2,218 eggs, averaging 2.45 ounces each.

It is seen therefore that the addition of cooked meat to an already adequate ration does not result in improved egg yields. On the other hand, the addition of this same quantity of cooked meat to a ration containing no animal protein causes a big increase in egg yield. In this trial, Group 2 birds were able to equal the egg yields from Group 1. It is clear therefore that cooked meat can replace meat meal in poultry rations so long as the total ration is capable of supplying all the nutrients required by the laying birds. Mixtures containing no animal protein, though they may provide the estimated nutrient requirements, are not so efficient for egg production as similar rations containing a small amount of animal protein.

NOTES ON ANIMAL DISEASES

Compiled by the Department of Veterinary Services, Kabete, Kenya

VII—FOOT-AND-MOUTH DISEASE

Foot-and-mouth disease is an acute febrile contagious disease, characterized by the appearance of vesicles in the mouth, on the feet or less commonly on other parts of the skin.

Etiology.—The historical discovery of Loeffler and Frosch in 1897, that foot-and-mouth disease lymph that had passed through a Berkefeld filter was still infective, was the first demonstration of a filtrable virus as the cause of a disease of animals or man. The virus may be kept for long periods in 50 per cent glycerine in the refrigerator, and, in the bone-marrow of a carcass dressed for the market and either chilled or frozen, has been found to survive for as long as 76 days. Dried on hay or bran, fluid from the vesicles may retain its infectivity for four to five months, provided that it is not exposed to high temperatures or to strong sunlight.

As with a number of other viruses, more than one type of virus exists, and by passaging the disease in guinea-pigs and then making cross-immunity experiments, three immunologically distinct types have been obtained. These are known as "O," "A," and "C." An animal that has been infected with type "O" virus and has recovered will resist further infection with that type, but is fully susceptible to infection with type "A" or "C". Similarly animals that have recovered from type "A" or "C" infection are resistant to the homologous strain but may be infected with the other two. Notwithstanding the immunological differences between the types, they all produce the same clinical picture, and it is quite impossible to state from the examination of a case what type of virus is responsible.

Recent experiments both at Kabete and in Europe show that a virus type is not fixed, and field observations suggest that during an extensive outbreak, after passage through large numbers of cattle, the type may become changed. The type most frequently present in field outbreaks in Kenya overlaps types "A" and "C".

In addition to varying in type, strains of foot-and-mouth disease vary in infectivity. Normally in Europe, foot-and-mouth disease is one of the most contagious diseases known; infection is easily transmitted to animals placed in buildings or on grazing recently vacated by infected stock, through movement of infected foodstuffs and manure, or even by farmers and others visiting infected and then healthy cattle and carrying the virus on their boots or clothing. On the other hand, outbreaks, the true nature of which has been confirmed by inoculation experiments, do occur occasionally in which the tendency of the virus to spread is low. One herd of cattle may become infected and another no great distance away may escape although no precautions to prevent spread are taken. Pigs on a farm may be infected without the disease spreading to the cattle.

It would appear that in the tropics the disease is generally of lower infectivity than it is in Europe, and it is rare for outbreaks to occur in Kenya except through the direct contact of infected and healthy stock.

Species susceptible.—Foot-and-mouth disease in nature is a disease of ruminants and swine. Cattle and pigs are highly susceptible; sheep and goats somewhat less so. In Europe, herds of deer are frequently attacked during epizootics in domesticated stock, but the disease does not appear to have been confirmed in wild ruminants in Kenya.

Experimentally, various rodents can be infected, and much investigational work is effected with guinea-pigs. The disease does not, however, spread naturally from infected to healthy rodents. The only small animal in which the virus habitually causes a serious disease and in which infection can occur by contact is the hedgehog.

Foot-and-mouth disease occurs in man, infection resulting either from the consumption of milk from infected cows or from the direct contamination of cuts with the virus.

Incubation period.—The incubation period following natural infection in stock is from two to seven days.

Symptoms.—The disease commences with a rise in temperature which during the first 24 to 48 hours may reach 105° C. Once vesicles develop the temperature falls to normal. Vesicles may form in the mouth or on the feet or at both sites. Less frequently, lesions are found on the udder, the nasal mucous membrane and in the air passages. The presence of lesions in the mouth leads to difficulty in

chewing. The animal eats slowly and salivates profusely. Lesions on the feet cause lameness which may persist for several weeks.

Wherever they form, the vesicles begin as small blisters containing a watery fluid which later becomes cloudy. The vesicles rupture, leaving isolated, red, raw sores, varying in size up to an inch or more in diameter. In the mouth they are usually found on the front half of the tongue, frequently quite close to the tip, but they may be present on the inside of the cheeks or on the gums. After two or three days the raw surface becomes covered with proliferating epithelium and if healing is normal the lesions heal completely after a few weeks. Often, however, the injured mucous membrane is invaded by bacteria such as the necrosis bacillus and pus-producing organisms, and a yellow or brown ulcer then persists for a month or more.

Lesions on the feet are to be found between the claws, around the top of the hoof and on the heels. One or all the feet may be affected. If the lesion occurs between the horny and sensitive structures, separation of the hoof may follow. Owing to their position, lesions on the feet are of course particularly susceptible to secondary infection by bacteria.

On the udder, vesicles usually occur on the teats and in the milk ducts. The milk becomes thick and yellowish-white in colour.

The local lesions of foot-and-mouth disease lead usually to marked general symptoms. There is a very heavy loss of condition, and even when the udder is not directly involved the milk yield of cows drops almost to nothing. Attacks in which general symptoms are mild, however, do occur in Kenya, and it has been suggested that virus from such outbreaks should be preserved with a view to its being used for the preventive inoculation of cattle when grazing conditions are favourable. There is, however, no reason to suppose that a virus isolated from a mild outbreak would continue to produce a mild disease in cattle as and when required.

Young calves frequently die suddenly without showing characteristic lesions of the mouth or feet. Death in these peracute cases is due to degeneration of the heart muscle, and although there has been considerable discussion as to the cause of this degeneration it seems probable that this is due to the direct action of the virus which is present in the circulation during the temperature reaction.

Post-mortem lesions.—The characteristic lesions found post-mortem are those of the mouth and feet that have already been described. In addition, other changes may be present: a varying amount of congestion or ulceration in various parts of the alimentary tract, swelling of the spleen, hæmorrhages on the heart sac and other serous membranes, pneumonia, and in rare cases swelling of the joints and ulceration of the joint membranes.

In calves that die suddenly the heart muscle has a characteristic dry, white appearance.

Complications.—Several complications are liable to follow an attack of foot-and-mouth disease. Secondary infection of the sores in the mouth and feet has already been mentioned. Lesions in the windpipe may lead to pneumonia and those in the udder to mastitis or the formation of abscesses.

A not uncommon sequel most often observed in heavy bovines, particularly pure-bred bulls in Kenya, is an infection of a small group of muscles, usually of a posterior limb, by *Corynebacterium pyogenes*. This may not be detected until a month or so after the animal has apparently recovered from its attack of the disease.

A further peculiar condition, now recognized as the result of an attack of foot-and-mouth disease, is the development of a woolly coat. This phenomenon, which persists for several years at least, is most frequently observed in Kenya in high-grade Ayrshire cows. In addition to the peculiar coat, such animals blow heavily after exertion; they are bad doers and should not be retained in the herd.

Mortality.—The mortality from foot-and-mouth disease in cattle and sheep is usually low, and the economic importance of the disease is attributable to the loss of condition and milk yield. Mortality from the disease itself is higher in calves and in pigs.

In certain parts of Europe it is generally held that the effects of the disease are more serious in stock in good condition; but in Africa there is no doubt that it is during times of drought that losses are greatest. Long treks in search of grazing and water can have but one effect on animals for whom both movement and eating are painful.

Treatment.—No drug with a specific chemotherapeutic action on the virus has as yet been discovered. This does not, however, mean that there is nothing that can be done to alleviate the effects of an outbreak of the

disease. Affected cattle should not be moved further than is absolutely necessary, and when possible they should be left to their own devices on green grazing, handy to water. The reservation of a couple of small paddocks close to a river as sick paddocks is one of the most useful improvements that can be made on farms in the dry districts of East Africa. Such paddocks will be found invaluable for the treatment of sick animals at all times.

During times of drought, supplementary feeding may be necessary. Green fodder crops are to be preferred, but in their absence a small ration of concentrates will be found useful.

Lesions may be treated with astringent, antiseptic lotions with advantage.

Vaccination.—No great progress has been made in the elaboration of a vaccine against foot-and-mouth disease. This is in part due to the difficulty in obtaining the virus in sufficient quantity in high concentration, and in part to the fact that any vaccine to be generally useful must be polyvalent. During 1938, German workers, following up the work of Danish investigators, produced a vaccine which appears to have given very favourable results in the preventive treatment of cattle during the European panzootic of that year. This vaccine is, however, by no means perfect and in addition its preparation is both complicated and expensive. Considerable improvement will be necessary before it can be considered suitable for use in East Africa.

Once a herd of cattle is infected, it is generally advisable to hasten on the outbreak by deliberately spreading the disease to all the cattle in the herd. It is most unlikely that any cattle in the herd will escape natural infection and the time, during which the infection is present and during which "nursing" of the herd is necessary, is shortened if virus from the vesicles of a natural case is collected on cotton-wool and rubbed on the mucous membrane of the mouth of the uninfected animals. By shortening the period during which infection is present on one part of the farm, the chances of spread to other parts of the farm and to neighbouring farms are reduced.

Isolated healthy herds may be quarantined. Where the strain of virus is of low infectivity and circumstances on the farm are favourable, quite simple measures may be successful. Healthy animals should not be allowed to come into contact with sick nor with recently recovered ones, nor should they pass over the same ground nor use the same watering-places. Native employees should be discouraged from moving from that part of the farm where the sick animals are kept to that occupied by the healthy ones, and the owner should, when necessary, visit the healthy herd first in the morning. Transport animals should not be allowed to pass between the two parts of the farm. Motor vehicles are less dangerous and easier to disinfect. It may be mentioned that the best disinfectants for use in buildings and for feeding utensils are a 1 per cent solution of caustic soda or of formalin. The former solution must not of course be used for disinfecting the hands, clothes, nor for foodstuffs. Cresol type disinfectants are much less effective.

On small, unfenced farms, where only one set of buildings is available, quarantine measures are not usually practicable.

SUPPLY OF DERRIS PLANTING MATERIAL

A considerable reduction has been made in the charges for Derris cuttings from certain official sources of supply. They are now offered at Sh. 2 per hundred by the East African Agricultural Research Station, Amani, and by the Department of Agriculture, Morogoro, Tanganyika Territory. Buyers should note the following conditions of sale:—

(1) All orders should be addressed to the Director of Agriculture in the territory in which the buyer resides and should be accompanied by a remittance to cover the cost of the cuttings and postage or transport by rail. The applicant will not as a rule have any means of knowing the latter accurately, and to save small cash adjustments the supplier will make up any difference by altering the number of cuttings actually sent.

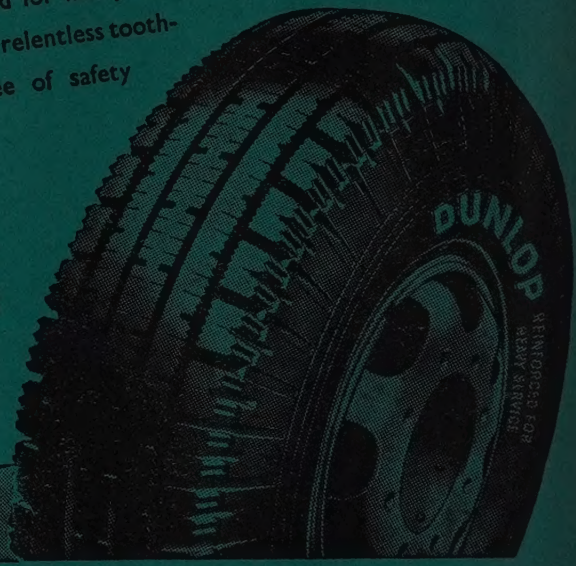
(2) While the supplier undertakes that the cuttings are despatched in good viable condition, he gives no guarantee of successful propagation by the recipient. Claims, for refund or for replacement, from recipients who have failed to establish the cuttings successfully cannot be entertained.

Intending planters should note the methods of propagation and planting described in the East African Agricultural Journal, Vol. VI, pp. 50-53.

Where the going's rough . . .

there's need for a tyre capable of titan service like the DUNLOP Giant. Powerfully reinforced for heavy duty, this long-enduring tyre is equipped with the unique, relentless tooth-tread that is a guarantee of safety on any surface.

BUY BRITISH AND CONSERVE STERLING CURRENCY



DUNLOP GIANT TYRES *with* TEETH

Depositaires—

THE AFRICAN MERCANTILE COMPANY LIMITED

Branches at Nairobi, Mombasa, etc.

PRINTED BY THE GOVERNMENT PRINTER, NAIROBI